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Vol. XVI. JULY, 1935 No. 61

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The Journal of Neurology and Psychopathology

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ISSUED BY THE BRITISH MEDICAL ASSOCIATION

LONDON: BRITISH MEDICAL ASSOCIATION HOUSE,
TAVISTOCK SQUARE, W.C.1.

Published Quarterly. Subscription 30/- per annum. Single Numbers 8/6 net. Post Free

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THE JOURNAL OF NEUROLOGY AND PSYCHOPATHOLOGY

Vol. XVI. JULY, 1935 No. 61

Original Papers

OBSERVATIONS ON THE MOTOR PHENOMENA OF HYSTERIA

By

I. M. ALLEN, Wellington, New Zealand

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I. INTRODUCTION

Positive evidence is necessary for the diagnosis of hysteria and hysterical manifestations; and, whether a superficial exploration of the psychological

background of the patient is made an essential part of the clinical examination or not, observation and appreciation of the physical phenomena of the disease cannot be omitted. That there are such physical phenomena is well known, but with two exceptions there have been no adequate investigations into the details of these phenomena and no attempt to determine their value as positive evidence, the method by which they are produced and the possible sources of confusion between them and physical findings which are regarded as evidence of structural damage in the nervous system. To be complete such an investigation must include examination by both physical and psychological methods, and the observation of the physical phenomena from time to time during the course of recovery under treatment by psychological methods.

The present communication deals with physical expressions of hysteria as they affect the motor system. An attempt is made to define and describe these physical expressions of the disease, to determine whether any general rules or laws are expressed by these phenomena and to decide whether there is any correlation between them or the general rules underlying them and the psychological issues involved in the conscious and unconscious personal problems of the patient. The phenomena described are readily accessible to examination and sufficient of them have been examined to ensure that any exceptions to or variations from general rules are evident.

II. METHOD OF INVESTIGATION

The investigation and the subsequent descriptions and conclusions are based on the examination of a series of 59 patients showing hysterical manifestations who have come under observation in hospital and consulting practice. In all of the patients a complete history of the illness has been taken and a complete physical examination has been made. The family history and the previous medical history, by symptoms as well as by names of diseases, have been recorded. The life history of the individual patient has been investigated in detail and, whenever it was decided that the condition was hysterical in origin, the patient has been explored psychologically to an extent necessary to remove symptoms and physical signs. From time to time during the course of recovery detailed observations were made on the motor phenomena.

In the early cases difficulty was experienced in observing the motor phenomena in detail. In some cases changes and variations occurred so rapidly that it was impossible to observe with any approximation to accuracy the changes which appeared and the sequence of events. Later it was found necessary to study a few cases under light hypnosis. In these cases it was found that a ' slow motion ' effect could be produced with some of the motor phenomena and the opportunity was taken of observing them under conditions suitable for the appreciation of detail and for the more accurate examination of the sequence of events. Later it became possible to observe these phenomena in the more rapid motion of the waking state. Hence the descriptions

and conclusions which follow are based on the observation of the motor phenomena in a few cases under light hypnosis and in the majority of cases in the waking state. Sensory, convulsive and other phenomena have been recorded as they arose and await further investigation, but are excluded from the present communication except in so far as they form part of the case histories quoted.

III. THE ESSENTIAL FEATURES OF THE MOTOR PHENOMENA

In this chapter the essential features of the motor phenomena are recorded, and the observations upon which their identification was based are summarised.

1. THE RESPONSE OF THE MUSCLES TO VOLUNTARY EFFORT AT COMMAND.—The response of the muscles to voluntary effort at command was studied by directing the patient to perform a definite movement involving the limb in which hysterical manifestations were present and then observing by sight and touch the effects produced. The following observations were made.

When the command was given to carry out a definite movement the patient made a conscious effort to perform the movement directed. No contraction or increase in tone occurred in the muscles which perform that movement. An increase of tone did, however, appear, and contraction occurred in the muscles opposed to that movement. That is, the agonists related to the movement directed failed to respond to the conscious stimulus and the antagonists responded completely and fully. As a result a strong movement was produced in the direction opposite to that directed.

Further detailed observations showed that the sequence of events was as follows. In response to command there were the intention and the conscious effort to perform the movement directed. The agonists became more atonic and failed to respond. The antagonists increased in tone and contracted, thus producing a strong movement as if the voluntary stimulus and the command had been directed towards the performance of that movement. The sequence of events was the opposite of that of the phenomenon of reciprocal innervation, though the essential features of contraction of one group of muscles and inhibition of the opposing group were still present.

The grosser features of contraction of antagonists and performance of the movement opposite to that directed were observed readily in the waking state; but the details of the inhibition of agonists followed by contraction of antagonists were observed with ease only in the slow motion effect of the light hypnotic state. Nevertheless, with practice in observation of the phenomena in the hypnotic state it became possible to observe the details in some parts of the body in the more rapid motion of the waking state.

For example, a patient in the waking state was directed to dorsiflex the foot (Case III). He made a conscious effort to do so. Tone diminished and no contraction occurred in the dorsiflexors of the foot. Tone increased and contraction occurred in the plantar-flexors of the foot, observations being

made in both cases by both sight and touch. This sequence of events was observed in slow motion under light hypnosis as well as in a more rapid form in the waking state.

The phenomenon of inhibition of agonists and contraction of antagonists in response to voluntary effort at command was the most common motor effect observed.

In other cases when the command was given to perform a definite movement the patient made a conscious effort to carry out that movement. No contraction occurred in either the simple agonists or antagonists related to that particular movement. A strong contraction did, however, occur in the muscles which fixed the limb in position for the performance of the movement.

When examined in more detail and more slowly it was found that on making a voluntary effort to carry out the movement at command there was a definite lowering of muscle tone in the agonists and antagonists related to that movement. At the same time or immediately afterwards muscle tone increased and contraction occurred in the muscles which fixed the limb in position for the performance of the movement directed. This phenomenon was regarded as an extension and more complex form of that characterised by inhibition of agonists and contraction of antagonists in response to voluntary effort at command.

For example, the patient was directed to flex the elbow. He made a conscious effort to carry out the movement. Diminution of muscle tone occurred in the flexors and extensors of the elbow, and an increase of muscle tone and strong contraction occurred in the fixing muscles at and about the shoulder joint.

In Case VI the patient was directed to close the hand and make a fist. He tried to do so, strong contraction occurred in all the muscles fixing and supporting the elbow and wrist, but no movement of grasping occurred. In this case it was very difficult on account of the grouping of the muscles to make any accurate observations on the long flexors of the fingers.

Considerable extension of this effect was observed. In the second example given above contraction occurred in the fixing muscles of the elbow as well as in those of the wrist. In another case, at one stage of recovery a patient suffering from hysterical paraplegia was directed to dorsiflex the right foot. There was diminution of muscle tone in the dorsiflexors and plantarflexors of the right foot, and strong contraction occurred in all the muscles which fixed the parts above the waist.

In some cases a more pronounced degree of inhibition of the motor impulse was observed. When the command was given to perform a movement and a conscious effort was made to obey the command, there was either absence of muscle tone in the agonists and antagonists from the beginning of the attempt or a sudden cessation of effort with atonicity of these muscles and sometimes of all the skeletal muscles.

A patient who was suffering from hysterical paraplegia was directed to

dorsiflex the right foot. An attempt was made to perform the movement; there was diminution of muscle tone in the dorsiflexors and plantar-flexors of the right foot, and contraction occurred in the fixing muscles of the trunk, upper limbs and neck. There was then a sudden cessation of effort and a loss of muscle tone not only in the right lower limb, but also in the left lower limb and of the muscles of the trunk, upper limbs and neck so that the patient fell back helpless on the bed.

This appeared to be a wide extension of the effect observed in the first motor phenomenon in the agonists only and in the second in the agonists and antagonists related to the movement directed.

That the degrees of development of these motor phenomena were variations of a single underlying method was indicated by the following observations made on a patient recovering from hysterical paraplegia. At the time they were made the hysterical motor phenomena remained only in relation to the movements of the left foot at the ankle. On the command to dorsiflex the left foot and conscious effort to do so, there was diminution of muscle tone and no contraction in either the dorsiflexors or plantar-flexors of the left foot. At the same time, strong contraction occurred in the muscles of the trunk, upper limbs and neck. At a later stage the same command and the effort to obey it resulted in diminution of muscle tone and absence of contraction in the dorsiflexors of the left foot followed by increase of muscle tone and contraction in the plantar-flexors of the foot. At a later stage still the same command resulted in increase of muscle tone and contraction of the dorsiflexors of the left foot and diminution of muscle tone in the plantar-flexors.

These observations confirmed the three motor phenomena described by Kinnier Wilson, namely: (1) Contraction of antagonists in place of agonists; (2) contraction of fixation muscles and absence of contraction in simple agonists and antagonists; and (3) complete absence of muscular response. They showed that the primary effect was inhibition of the motor impulse to the muscles required for the movement directed, and that with it or consequent to it there was transmission of the motor impulse to the opposing muscles. According to the relative preponderance of inhibition of agonists and contraction of antagonists the three motor phenomena described above were produced.

2. THE RESPONSE OF THE MUSCLES TO SPONTANEOUS VOLUNTARY EFFORT. —The direct investigation of the response of the muscles to spontaneous voluntary effort was more difficult as the opportunity had to be taken of making independent and scattered observations at times when the patient tried of his own accord to perform movements. Nevertheless, by piecing together individual observations on different patients, it was confirmed that the grosser manifestations of the motor phenomena occurred in exactly the same way as they did when conscious effort was made to carry out the movement at command.

These features were studied particularly in a patient with hysterical drop-foot of 14 years' duration (Case I). On examination of the muscular response to voluntary effort at command it was found that in response to the command to dorsiflex the right foot the dorsiflexors of the foot showed a diminution of muscle tone and failed to contract, the plantar-flexors showed an increase of muscle tone and contracted, and a strong movement of plantar-flexion resulted. Thus far the findings were in keeping with the first motor phenomenon described above. When the patient began to walk up and down the room there was at first a slight degree of drop-foot on the right side. As he proceeded, however, the drop-foot became more pronounced and walking became more difficult. Examination at this stage showed relaxation of the dorsiflexors of the foot and strong contraction of the plantar-flexors with elevation of the heel. Later both dorsiflexors and plantar-flexors were contracted and the foot was maintained in a position of full plantar-flexion. These observations agreed with the history of the disability on different occasions. The patient stated that when he began to walk he moved his right foot without great difficulty though it was a little awkward. As he walked farther the drop-foot became more obvious, and finally it was necessary for him to seek help to return home. In this case it was accepted that in walking with a slight degree of drop-foot there was conscious effort to keep the toes of the right foot clear of the ground on taking each step. With each effort to do so there was produced a greater degree of drop-foot as a result of inhibition of the motor impulse to the dorsiflexors and contraction of the plantar-flexors; and as a final result the drop-foot became so pronounced that the patient was unable to walk farther in comfort.

Similar observations were made in relation to the second motor phenomenon. A patient who was suffering from hysterical drop-wrist (Case V) made an effort to place the left hand on the table at a time when the right hand was not free to lift it. There was no response whatever in either the flexors or extensors of the wrist, but strong contraction occurred in the fixing muscles at the elbow and shoulder, and an attempt was made by rotating the body to swing the left hand into position on the table. Similarly, a patient who was suffering from hysterical paraplegia (Case II) was observed at a time when it was necessary for him to change his position in bed. No contraction occurred in the muscles of the lower limbs, but strong contraction occurred in the muscles of the trunk, upper limbs and neck. With these muscles fixing the upper part of the body as a more or less rigid whole the lower limbs were dragged like dead weights from one part of the bed to another.

The third motor phenomenon was seen frequently in response to spontaneous effort in those patients in whom the inhibitory factor was most pronounced. The patient tried to perform a movement such as raising the right hand to the head; some contraction of muscles occurred and some movement took place; there was then a sudden cessation of effort, the right

upper limb fell helpless at the side and on immediate examination the muscles of all parts of the limb were found to be extremely hypotonic.

Though it was impossible from the nature of the observations to confirm every point in detail, there was sufficient evidence to show that the motor phenomena produced in response to voluntary effort at command were the exact counterparts of those produced as a result of spontaneous effort. It followed also that the bizarre effects and contrary responses were produced entirely as a result of factors within the patient and not as a reaction to the observer or the authority issuing the command. The study of the motor phenomena of hysteria, therefore, resolved itself into the study of the territory between the conscious and unconscious levels of the personality as represented in the cerebral cortex and the muscles involved in the production of the motor response.

3. THE NEUROPSYCHOLOGICAL LEVEL OF THE DISABILITY.—It was necessary at this stage to examine the evidence which determined the neuropsychological level at which the disability was produced in the cases which formed the basis of the investigation.

In the patient referred to above in whom there had been hysterical drop-foot for 14 years the following observations were made. In response to the command to dorsiflex the right foot and the conscious effort to do so there was diminution of muscle tone and absence of contraction in the dorsiflexors of the foot. There followed increase of muscle tone and contraction in the plantar-flexors of the foot with a strong movement of plantar-flexion. On the further command to invert the foot and the conscious effort to do so there was increase of muscle tone and contraction in tibialis anticus and decrease of muscle tone in the peroneal muscles. A strong movement of inversion of the foot resulted. That is, in response to the command to perform one movement a muscle was inhibited and in response to the command to perform another movement the same muscle contracted. In each case a motor impulse was transmitted without interruption from the motor level of the cortex to a muscle, though in one case the destination of the impulse varied from that intended. There could be no abnormality of neural function at or below the level of the motor cortex.

Further, the command to perform the movement was heard normally and transmitted to the higher cortical level. The patient heard the command, understood it, and was able to express in words what he intended to do. It followed then that the disability was either at the higher cortical level or somewhere on the path between it and the level of the motor cortex. This path was, however, excluded by the normal response of inversion of the foot at command in the example given above.

On further examination of what occurred when a hysterical motor phenomenon was produced in response to the command to perform a definite movement the following observations were pertinent. In a particular case the command was heard and appreciated as a command to dorsiflex the right

foot. The patient made an effort to dorsiflex the right foot. Strong plantar-flexion of the foot resulted. The patient expressed surprise that the foot was moving down when he was told or shown what was occurring. Also, when he was prevented from seeing the foot concerned, he was often unaware that any movement plantar-wise was occurring and even protested that he was unable to obey the command after he had tried to do so. Immediately, however, he became aware that the foot was in a position of plantar-flexion and expressed surprise that it was so. Appreciation of changes in the position of the toes was normal when they were produced by passive movement. It seemed that the abnormal motor response was produced at the unconscious level and was not under conscious control by the patient. It consisted primarily in inhibition of the impulse transmitted from the conscious level and, secondarily, in the substitution for it of an impulse which had an opposite effect in terms of movement. Furthermore, with the exposure and conscious resolution of conflicts previously hidden at the unconscious level or the uncovering of factors in the personality previously repressed to the unconscious level, the condition passed through a phase of complete inhibition of the conscious motor impulse with the substitution of an impulse to fixation muscles, inhibition of the motor impulse with the substitution of an opposite effect in terms of movement, and finally full transmission of the conscious motor impulse.

4. THE RESPONSE OF THE MUSCLES TO CUTANEOUS STIMULI AS OBSERVED IN CUTANEOUS REFLEXES.—The two groups of cutaneous reflexes which offered themselves for study were the abdominal reflexes and the plantar reflexes, of which the latter were more suitable and convenient for initial study. It was necessary for the study of these reflexes in relation to the motor phenomena of hysteria that the patient should be conscious of the stimulus in the sense that the sensory stimulus which initiated the reflex response should be conveyed to the cortical level and be appreciated consciously by the patient. Hence, for convenience in observation, patients in whom there was hysterical anæsthesia or analgesia in the area of stimulation were unsuitable subjects for study. Since the admissibility of evidence elicited in light hypnosis might be questioned the description and conclusions were based entirely upon observations made in the waking state.

In the first case studied (Case II) only the plantar reflexes were observed. The right lower limb was the subject of study throughout. Examination in the waking state was made both before and after an examination in light hypnosis, the character of the responses and the sequence of events being confirmed by an independent observer who had no knowledge of the possible results. In the waking state it was difficult to secure full relaxation of the hamstrings and of extensor longus hallucis, though relaxation of extensor longus digitorum was secured with comparative ease. In this condition the application of a stimulus by stroking forwards along the outer side of the sole of the foot resulted in further contraction of extensor longus hallucis, an

upward movement of the great toe, contraction of the hamstrings and to a lesser extent upward movement of the small toes, and especially of the second and third toes. Increase of tone and tension was both visible and palpable in the tendons of extensor longus digitorum. With a less obvious degree of the same condition—hamstrings and extensor longus digitorum relaxed, but some tension still present in the tendon of extensor longus hallucis—the application of a stimulus in the same way resulted in upward movement of the great toe and to a lesser extent upward movement of the small toes. It was possible, though difficult to observe accurately on account of the rapidity of the response, that contraction of the hamstrings preceded or was simultaneous with that of the extensor of the great toe. With adequate relaxation of all the muscles of the lower limb, and especially of those named above, the application of the stimulus produced no response whatever.

The more detailed examination of the response of flexors and extensors to a plantar stimulus was difficult to secure under conditions which permitted adequate comparison of the responses in a hysterical limb with those in a normal limb. Eventually, however, there came under observation a young man who had developed right hysterical hemiparesis in response to an emotional situation (Case III). In the right upper limb there were found the characteristic motor phenomena described above, including transmission of motor impulse to antagonists in place of agonists and transmission of motor impulse to fixation muscles in place of simple agonists and antagonists. Similar characteristic motor phenomena were seen in the right lower limb. Observations were made on the two lower limbs. By palpation and manipulation of the great toe and of the small toes the tendons of flexor longus hallucis and of flexor longus digitorum were identified on the outer and inner sides respectively of the tendo Achillis. On application of the stimulus to the outer aspect of the sole of the left foot these tendons contracted at once with flexion of the great toe and of the small toes. On the right side there was some contraction of the tendon of extensor longus hallucis which was difficult to overcome. This was reduced as far as possible. Then, on application of the stimulus to the outer side of the sole of the right foot, relaxation of the flexors of the toes occurred at once and was followed by contraction of the extensors with a movement of extension, at first of the great toe and later of the small toes. The upward movement of the great toe was at first rapid and then proceeded more slowly. The contrast in the behaviour of the two flexor tendons in the healthy limb and in the hysterical limb was readily appreciated.

The findings in response to the stimulus were contrasted with those in the normal subject, those in a subject in whom there was interruption of the motor path involving the upper motor neurone, and those in a subject in whom a lower motor neurone lesion affected the flexor muscles of the toes and spared the extensors. In the normal subject the stimulus to the sole of the foot resulted in strong flexion of the great toe and of the small toes. With a stronger or more prolonged stimulus there was associated with this

response dorsiflexion at the ankle and flexion of the knee and hip. In the subject with interruption of the motor path in the upper motor neurone the stimulus to the sole of the foot when the limb was flexed and relaxed resulted in slow extension of the great toe, contraction of tensor fasciæ femoris and fanning of the small toes; and in addition dorsiflexion at the ankle and flexion of the knee when the stimulus was strong or prolonged. In the subject with a lower motor neurone lesion affecting the flexors of the toes and sparing the extensors the stimulus resulted in extension of the great toe and of the small toes.

In the hysterical state, with full communication between the area of stimulus and the cortex, the stimulus resulted in inhibition of the flexors of the toes and absence of the normal flexion response in all the toes. Further development of this effect was seen especially when tension or contraction was maintained in the extensors of the toes. Under such conditions not only did the stimulus to the sole of the foot result in inhibition of the flexors of the toes and absence of flexion of the toes, but increase of muscle tone and contraction followed in the extensors of the toes with extension of the great toe to a greater extent than that of the small toes. Thus there was produced a result similar to that with the lower motor lesion mentioned above and resembling superficially that produced as the result of a lesion of the upper motor neurone.

It was confirmed that, with full sensory communication between the area of stimulus and the cortex, the phenomenon of inhibition of agonists and contraction of antagonists came into operation in response to the cutaneous stimulus in the same way as in response to spontaneous conscious effort and to conscious effort at command.

5. THE RESPONSE OF THE MUSCLES TO STRETCH.—The response of the muscles to stretch in the hysterical limb was studied by putting individual groups of muscles and when possible individual muscles under tension by means of passive movement and in eliciting individual tendon reflexes. Observations were made also on the response of groups of muscles to the contraction of opposing muscles in limbs or portions of limbs which showed the motor effects of hysteria.

The normal response has been summarized as follows. ' If the tendon of a healthy muscle is drawn upon by an antagonistic muscle or by the manipulation of the observer or by the movement of a joint in response to gravity, the muscle actively resists the extending force. A muscle which has been paralysed by section of its motor nerve or of the ventral or dorsal roots supplying it does not actually resist and behaves like a piece of non-contractile tissue such as the skin. The muscle is flaccid. The resistance, however, from a muscle in full connexion with the nervous system is a reflex contraction, " the stretch reflex " ' (R. S. Creed et al., 1932).

In the hysterical subject the following observations were made. In muscles which had normal muscle tone stretch resulted in the appearance of

normal and increasing resistance which depended upon the degree of tension. When muscles which showed an increase of tone were put under tension there was in addition to the original resistance a further gradually increasing resistance which soon made further movement impossible. When the muscles were flaccid or appeared to be so, as in some cases of hysterical paralysis, there appeared to be little or no resistance to the first few movements which put the muscle on stretch, but later definite resistance of the muscles under tension appeared and increased as the tension increased. It appeared that, with hysterical paralysis of this type, it was necessary to bring the stretch above a certain threshold by repeated movements of stretch to elicit the normal stretch reflex. When a limb or a part of a limb was exposed to the action of gravity—such as the forearm, the foot or the toes—the muscles which counteracted the effect of gravity were maintained in a condition of increased tone and any hysterical motor effect in the form of tonic paralysis was usually more pronounced in that group of muscles than in any other group. Finally, in a portion of a limb in which the phenomenon of shunting of the motor impulse into antagonists could be demonstrated, the command to perform a movement or the spontaneous attempt to perform a movement resulted in inhibition of agonists, contraction of antagonists, and then in gradually increasing resistance and increase of muscle tone in the agonists. The same sequence of events was observed in response to a cutaneous stimulus as in eliciting the plantar reflex.

The observations showed that with hysterical motor involvement of the limb the essential and gross features of the stretch reflex as seen in the clinical subject differed in no respect from the normal. The response of the tendon jerk depended upon the balance of muscle tone originally existing between the muscles subjected to stretch and those which opposed their action. The final response in a reflex such as the plantar reflex depended upon the same balance of muscle tone existing between those muscles which normally contracted in response to the stimulus and those which opposed their action. Under favourable conditions, when increased tone existed in both groups of opposing muscles, stretch to one group by tapping the tendon or passive movement resulted in alternating contraction and inhibition of the two groups of muscles and a condition of clonus. Such an effect was observed also following a voluntary movement in one direction by the patient and at times in a tonic limb which appeared otherwise to be at rest.

6. Summary of the motor effects of hysteria.—In a limb which showed motor effects of hysteria it was established that in response to conscious effort at command, spontaneous conscious effort or cutaneous stimulation as in the eliciting of the plantar reflex there was inhibition of the motor impulse to the agonists related to the movement intended or that which occurred normally in response to the cutaneous stimulus. In extreme examples this was the only effect. In less severe cases the motor impulse to the agonists was replaced by a motor impulse to the fixing muscles; and in

still less severe cases to the antagonists. The final result in terms of movement depended upon the original balance between agonists and antagonists, and the relative preponderance of inhibition of the impulse to agonists and transmission of the impulse to antagonists. Further effects depended upon the presence of the normal stretch reflex in opposing groups of muscles. It was indicated further that the inhibition of the normal motor impulse to agonists and the replacement of it by a motor impulse to antagonists were the result of factors operating at the unconscious level of higher cortical functions.

IV. CERTAIN CLINICAL MANIFESTATIONS OF THE MOTOR PHENOMENA OF HYSTERIA

In this chapter certain of the more clinical manifestations of the motor phenomena of hysteria are described and discussed, and attention is directed to variations in common physical signs.

1. Tonic paralysis.—The term 'tonic paralysis' is used to indicate the condition of increased muscle tone with limitation of active movement in response to conscious effort, which may exist with hysteria, to distinguish it from the spastic condition of the limb affected as the result of a lesion of the upper motor path and from the rigidity associated with extrapyramidal lesions.

Simultaneous tonic contraction has been observed in opposing groups of muscles with immobility of the limb to conscious effort, either voluntary or at command. The position of the limb in this condition is neither characteristic nor uniform, and may vary from the extreme position produced by contraction of one group of muscles to that produced by contraction of the opposing group. The position is often one of balance between the two groups. When, however, a local protective effect results from the tonic paralysis or the limb or a portion of the limb is subjected to the action of gravity, the balance of contraction may be in favour of the protection in one case or against the action of gravity in the other.

In the lower limb tonic monoplegia or paraplegia results. In a mean position the knee is extended, the foot slightly plantar-flexed, the small toes in a natural position and the great toe slightly extended. The foot may be maintained in a position of dorsiflexion or of full or partial plantar-flexion. The toes may be slightly extended and often the great toe is extended more than the small toes. The knee may be fully extended, slightly flexed or flexed beyond 90 degrees.

In the face a more or less rigid mask-like condition results, resembling superficially the fixed facies of extrapyramidal rigidity. This has been the clinical feature most often observed in the patients under review. The increased tone of the facial muscles is also evident on palpation and increases on palpation. Since the condition is rarely complete in the face the immobility of the musculature is relative rather than complete. In response to voluntary

effort at command, as in showing the upper teeth, the movement begins slowly, proceeds slowly, and is limited in extent. The same features are observed when the patient smiles, the result being a slow, rigid and limited movement which can be accepted as a smile only because the circumstances seem to warrant such a response. The movement in response to voluntary effort is often more extensive than that in response to emotion. In some cases this relative immobility of the face is more pronounced on one side, and, indeed, may appear to be confined to one side. Attention has been drawn to this unilateral effect in a study of dissociation of voluntary and emotional movements of the face, when it was observed as dissociation of the two types of movement in some patients suffering from conditions of a psychological nature. In addition, with initiation of the voluntary movement of the face, as in showing the teeth at command, on the slightest attempt to perform such a movement spontaneously and when speaking, an alternation of up and down movements appears and produces the effect of a series of clonic movements in the rigid facial musculature. Usually this tremor is observed more readily clinically than the actual rigidity of the facial musculature, for the latter may be mistaken for the normal facies of the patient. In some cases there may be relative freedom of the facial movements in response to emotion and when speaking, a condition which adds in some degree to the appearance of euphoria of the hysterical subject with an organic symptom. These variations from the normal in the facial musculature and the movements of the face are very common in the hysterical subject, and in many patients suffering from hysterical effects other than the motor may be the only motor and objective phenomena observed.

Often there is moderate increase in tone of the intercostal muscles which becomes more rigid on palpation. When observed superficially the limitation of thoracic movement with respiration may suggest paralysis of the intercostal muscles.

The muscles of the abdominal wall are often rigid, either alone, with rigidity of the facial muscles, or with more widespread motor phenomena. The rigidity increases on palpation and is little affected by raising the knees or engaging the attention of the patient. The abdominal reflexes are much diminished or fail to respond, and the respiratory movements are limited or absent. With the eyes closed, the knees raised and regular breathing established, it is sometimes possible to elicit a response to the first stimulus. In that case the movement is abrupt, terminates abruptly, and is followed by an abrupt return to the original position. In most cases, however, the stimulus is followed by what appears to be a more rigid maintenance of the position at the middle line. When such hysterical motor abnormalities of the abdominal musculature are associated with pain in the abdomen, the probability of unnecessary surgical exploration is much increased. Such a case was Case VII.

2. TONIC PARALYSIS WITH CONTRACTURE.—Tonic paralysis with contrac-

ture has been indicated above as a balance of contraction of two opposing groups of muscles against a force such as gravity, or in favour of a protection which is still necessary or no longer exists. That against gravity is of particular importance when it affects, as it commonly does, the extensor longus hallucis and the extensor longus digitorum muscles; for under such conditions the examination and interpretation of the plantar reflex become very difficult. Balance of contracture in favour of protection is illustrated by two cases. In one case there was balance of contracture in favour of the flexors of the left elbow when the skin in front of the elbow had been injured and healed some months before. Detailed examination revealed inhibition of agonists and contraction of antagonists in response to effort both spontaneous and at command whether flexion or extension of the elbow was attempted. The second case was that of a girl who became excited when in the company of a man. Spasm of the adductors of the thighs appeared, and there developed gradually tonic contraction of the abductors and adductors with the balance of contraction in favour of the adductors. In the course of one year the thighs became rigidly adducted and tenotomy was necessary before undertaking treatment of the underlying conflict.

3. Tonic paralysis with tremor.—Tonic paralysis with tremor has been observed in the limbs, the tongue, the larynx and the facial muscles. Instead of the opposing groups of muscles remaining at rest in a condition of increased tone, as in the form of tonic paralysis described above, there is an alternation of movement in favour of the two groups in turn with consequent tremor on a basis of muscular rigidity. The tremor is regular, the movement is backwards and forwards along the same path, and on palpation the alternating contraction of the opposing groups of muscles can be felt easily by the observer. Examined in detail, it appears that this 'tonic tremor' is an incomplete form of tonic paralysis and develops in the following way. The original volition results in inhibition of agonists and contraction of antagonists, agonists are put on stretch and contract, and there appears a basis of tonic paralysis which varies in degree in the individual patient. With incomplete tonic paralysis the alternation continues in the form of readily appreciated contraction of agonists and antagonists with the appearance of tonic tremor. It may be present at rest, but most often it is initiated by voluntary effort to perform a movement involving the use of the limb affected or by the application of a local stimulus which produces stretch of one group. With the former the effort to perform the movement directed results in contraction of the antagonists, the agonists are at once put on stretch and contract, the agonists and antagonists then contract alternately, and the resultant movement then continues for a varying period. In a limb in a condition of tonic paralysis putting one group of muscles on stretch by tapping a tendon or passive movement may initiate a series of such contractions and cause tonic tremor to persist for as long as half an hour after the stimulus is removed, or in the case of passive movement as long as the limb

is held in the new position. In this way patellar clonus and ankle clonus may be produced.

4. MINIMUM TONIC PARALYSIS WITH MAXIMUM TREMOR.—In some cases and in individual groups of muscles the tonic paralysis is slight or absent, and, under suitable conditions, the tremor is freer and more pronounced. When the patient extends the upper limbs and fingers before him at command a slight up and down tremor appears in the extended fingers and increases as long as the fingers are maintained in that position. On examination this is found to be due to contraction of the flexors and extensors of the fingers alternately from the time the attempt is made to maintain them in position. The primary impulse is to contract the extensors to obtain the position directed, and then from the operation of the agonist-antagonist motor phenomenon and the stretch reflex the tremor develops and becomes more pronounced as further voluntary efforts are made to maintain the position. A similar effect is observed in the upper eyelids on closing them gently at command. In either case a pronounced voluntary movement in one or the other direction causes the tremor to cease. The tremor thus produced is a loose, regular tremor whose movement passes backwards and forwards through the same path, and differs from the tonic type of tremor only in the greater freedom of excursion and the absence or slight degree of the tonic element.

5. THE EFFECT OF THE MOTOR PHENOMENA ON THE TENDON REFLEXES.—To a great extent the effects of hysterical motor disabilities upon the tendon reflexes are evident. The effects are due entirely to local muscular conditions, though, as indicated above, the factors which produce these conditions are operating at the highest level of the nervous system. When there is a minimum tonic condition the tendon reflexes are exaggerated—the latent period is reduced, the rise is abrupt and more extensive than usual, the cessation of the movement is abrupt and the return to the original position is abrupt. When there is tonic paralysis with tonic tremor the same features are apparent, but the excursion is very slight. When a position of tonic rigidity is maintained or the limb is flaccid the tendon reflexes cannot be elicited. When there is tonic paralysis with the balance of contraction in one direction, there is an abrupt and either small or extensive response with the tendon reflex which operates normally in the direction of the balance of contraction, and an absent or minimal response with a reflex operating in the direction of lesser contraction.

6. THE EFFECT OF THE MOTOR PHENOMENA ON THE PLANTAR REFLEX.—Difficulties in the examination and interpretation of the plantar reflex are common and doubt has been expressed as to the simplicity of the observation and interpretation of the phenomena upon which the identification of the extensor response associated with structural damage is based. That there are such difficulties is illustrated by the following case reported by Fox in 1922, and by Cases II and III.

'From the time this sign was first described by Babinski we have been taught and have reverently bowed the knee to its organic significance. From time to time some diffident suggestions have appeared that possibly it might be liable to variation but I have never seen any definite statement impugning its reliability. . . . I have under my care a marine. . . . He was first admitted in December 1919 with a provisional diagnosis of spinal tumour. . . . He had over eighteen years' continuous service, with no history of any previous illness. . . . He complained chiefly of intense pain in the back, with extreme rigidity of the legs which quite prevented him from walking. At night he frequently had "war dreams" in which he cried out and disturbed the ward. The rigidity was very marked and I could only flex his knees with the greatest difficulty. The patellar reflexes were very active; ankle clonus was present on both sides; the plantar response was always readily obtained, and was consistently extensor in type. He had anæsthesia extending equally and completely over both legs, but above that sensation was normal. It seemed to me to correspond fairly well with the cases of astasia one met with during the war. He gradually recovered and was discharged in June 1920. . . . One day he had a fall, when all his old symptoms reappeared, and in March 1921 he was readmitted. . . . His condition then was by no means so severe as when first seen. The rigidity, however, was still extreme, ankle clonus just as readily obtained and the extensor response the same as before. His recovery this time was very slow. . . . The extensor response for a long time never varied, then as the rigidity of the legs decreased it also became less marked; then it would be present on one side and not on the other; then it would be absent on both sides in the morning, returning if he was tired in the evening. . . His war history was not beset with any startling incidents; the only event which has possibly some bearing on his disorder was that once while coaling at sea a friend of his had both legs badly crushed.'

The effects of hysterical motor phenomena on the plantar reflex are of great practical importance because of the attention paid to the abnormal plantar reflex and even to individual aspects of it to the exclusion of other features as evidence of motor path damage. These effects depend upon the balance of tone in the hysterical lower limb often being in favour of the extensors of the toes, and particularly of the great toe, as against gravity and the sequence of inhibition of agonists, contraction of antagonists and stretch with contraction of agonists being produced by the recognized sensory stimulus in exactly the same manner as by voluntary effort, either spontaneous or at command.

With tonic paralysis of the lower limb and the balance of tone against the action of gravity extensor longus hallucis is contracted either alone or to a greater extent t' an extensor longus digitorum. In this condition the application of a nocuous stimulus to the outer side of the sole of the foot results in inhibition of the flexors of the toes and contraction of extensor longus hallucis with a movement of extension of the great toe. When the stimulus to the sole of the foot is more prolonged or more acute the small toes also extend, but to a lesser extent than the great toe. In some cases the hamstrings may contract too. In each case the movement of extension of the great toe is at first rapid and becomes slow only when the previously inhibited flexors are put on stretch and begin to contract. Superficial observation of the response when the great toe extends and the small toes fail to move

may lead to the interpretation of the changes as those of the extensor plantar reflex associated with a lesion of the upper motor path.

When, in a lower limb affected by tonic paralysis, there is a normal position of balance between the flexors and extensors of the toes produced either as part of the tonic paralysis or by securing relaxation of the extensors, a nocuous stimulus to the sole of the foot produces inhibition of the flexors and contraction of the extensors, but the normal balance is disturbed only enough to prevent flexion of the toes. No movement of the great toe or of the small toes results. This is the absence of the plantar response in some cases of hysteria described by Buzzard. It may be observed as a manifestation of hysteria in patients in whom there is no evidence of gross motor disturbance in the lower limbs or elsewhere, but in whom detailed examination may reveal minor motor changes of the type described in the facial muscles and elsewhere.

When the lower limb is flaccid in the course of hysteria a stimulus to the sole of the foot produces no response. Repeated stimuli may, however, produce the condition of a balance of tone between the flexors and extensors described above, and in a favourable case the response goes through phases from absence of response with flaccidity of muscles, absence of response with balance of tone between flexors and extensors, and a slight movement of extension of the great toe to extension of the great toe to a greater extent than of the small toes. When the motor phenomena are disappearing in the course of treatment the sequence is from extension of all the toes to extension of the great toe without movement of the small toes, balance of tone with no plantar response, and normal contraction of the flexors and inhibition of the extensors in response to the stimulus.

The sources of error in the examination and interpretation of the plantar reflex in the hysterical subject are evident. The responses observed depend entirely on the motor phenomena described as characteristic of hysteria and are in no way dependent upon diminution or absence of sensation at the site of application of the stimulus. Cases in which sensation was absent or diminished have been excluded from the material upon which these conclusions are based. Diminution or absence of sensation on the sole of the foot does, however, introduce an additional factor when present, but only to the extent of reducing or interrupting the afferent stimulus.

V. SUMMARY AND CONCLUSIONS

1. Observations have been made over a period of five years on patients who were the subjects of hysteria with particular reference to the disturbances of motor function.

2. A series of 59 such patients has been investigated by clinical methods and psychological exploration; and detailed examination of disturbances of motor function has been made both at the time the patient came under

observation and at intervals during the stages of recovery associated with psychological exploration.

3. The essential and primary effect in the motor system is inhibition of the motor impulse to the muscle or group of muscles which in the normal subject would contract in response to that impulse.

4. Inhibition of the motor impulse arises at the unconscious level of higher cortical functions and is produced by either a conflict in the personality, both sides of which are excluded from consciousness, or by that factor in a conflict which is excluded from consciousness to allow the other factor to control the conscious life of the personality.

5. The immediate motor effect is inhibition of agonists, and is followed by contraction of antagonists or of fixation muscles. According to the degree of inhibition the clinical effects, in order of lessening severity, are flaccidity of muscles in the part concerned, flaccidity of muscles with contraction of fixation muscles, and failure of agonists to contract followed by contraction of antagonists. The last-named is the most common motor phenomenon.

6. These effects are produced in the same way whether the original motor impulse arises as a result of voluntary effort, voluntary effort at command, or in response to a sensory stimulus as in eliciting the plantar reflex.

7. The stretch reflex acts normally in the muscles of the hysterical limb, though, when the muscle is flaccid, tone is usually below the threshold at which the reflex comes into action and repeated or prolonged stretch is needed to bring it above that threshold.

8. Local motor phenomena arise as a result of inhibition of agonists, contraction of antagonists, the application of stretch to agonists and contraction of agonists in that order.

9. Hysterical tonic paralysis, tonic paralysis with contracture, tonic paralysis with tremor, tremor with minimal tonic paralysis and tremor are described as they occur in the hysterical subject, and their development shown to depend upon the sequence of effects indicated under (8).

10. Attention is drawn particularly to the clinical effects of these phenomena in the face, abdominal muscles and the lower limb.

11. The effect of hysterical motor phenomena on tendon reflexes and the plantar reflex is described; and attention is drawn to the need for attention to every detail in the examination and interpretation of the plantar reflex.

APPENDIX

Illustrative Cases

The following cases have been chosen from those on which the investigations were made to illustrate the physical and psychological accompaniments of the motor features detailed above. The physical features are described in full; the psychological situations are summarised.

Case I.—W.R., male, age 45 years, was referred by the War Pensions Appeal Board on August 14, 1934, when he complained of partial drop-foot on the right side.

In 1918 he received a wound above and behind the right knee and thereafter for two years suffered from drop-foot due to partial interruption of the external popliteal nerve. He wore a support until 1925. When he began to walk his right foot 'flopped' a little, but after walking about one mile it dropped completely and became difficult to control. Until two years ago he was able to continue his work as a builder with his disability as he could employ men to do his labouring work. Since then he had been unable to have assistance and his disability became worse. For one year sleep had been interrupted and he had been worried by adverse financial circumstances.

On examination the functions of the central nervous system were normal with the exceptions to be described; and no abnormalities other than well-healed scars and a congenital abnormality in the left side of the neck were found in the rest of the examination. A slight tremor appeared in the fingers on extension. At the right hip and knee joints all voluntary and passive movements were normal. Movements at the right ankle and of the toes were affected in the following way. When told to bend the right foot down an attempt was made to do so. There was decrease of tone in the muscles of the anterior compartment of the leg following increase of tone in the muscles of the posterior compartment. These muscles contracted and a strong movement of plantar-flexion resulted. When told to bend the right foot up there was relaxation of the muscles of the anterior compartment followed by contraction of those of the posterior compartment and less pronounced plantar-flexion resulted. Passive movement of the foot resulted in contraction of the muscles of the posterior compartment and finally cessation of the movement of dorsiflexion. At command the toes flexed normally but extension was limited. When told to turn the foot in there was strong contraction of tibialis anticus and good inversion resulted. Eversion was normal. At rest the foot was held partly plantar-flexed with some contraction of the muscles of the posterior compartment. On the outer side of the leg in its upper two-thirds there was an extensive area of loss of sensation to pinprick. This extended upwards to immediately below the knee. The left ankle jerk was normal and the right limited. The left plantar reflex was flexor and the right gave no response.

Examination of the personal history showed that he re-entered civil life with uncertainty as to his capacity to meet it on account of the wound of the right knee. He had been obliged to pass from commissioned rank to his ordinary occupation. Adverse personal and financial circumstances aggravated the situation. The hysterical disability probably represented the terms upon which it was possible for him to re-enter civil life.

Case II.—A male, age 23 years, was admitted on March 3, 1934, complaining of weakness of the legs of four weeks' duration. Four weeks before his legs became suddenly weak, improved for a few days and then became slightly worse. There was numbness of the legs from the hips. He had pleurisy with effusion two years before. On admission he walked in a clumsy manner, all movements of the lower limbs were clumsy in the recumbent position, and the tendon reflexes were exaggerated in both upper and lower limbs. When seen personally the next day there was a tonic to-and-fro tremor in the facial muscles, and limitation of both voluntary and emotional movements of the face. There was a similar to-and-fro movement of contraction and relaxation in the left quadriceps muscle. It was difficult to secure relaxation of the abdominal wall; but with slight relaxation the first abdominal reflex elicited immediately after was normal. In all other respects the physical examination was negative. Following this examination the physical disabilities disappeared, and the patient was discharged at the end of two weeks with tremor of the facial muscles as the only physical sign.

He was readmitted two weeks later. For two days after his return home he had been normal. Then weakness of the legs and numbness of the lower limbs and trunk supervened rapidly. On readmission the house physician's examination revealed

diminution of sensation for pinprick and cottonwool below the second rib, weakness of the abdominal muscles, slight weakness of the legs in the recumbent position, a shuffling and drunken gait, and plantar reflexes recorded as doubtful extensor. After being threatened with laminectomy for spinal tumour, he was seen personally one week later. The finding of many contradictory physical signs rendered that position untenable. Meanwhile, the disability had become much worse. The cranial nerves and upper limbs were normal. The intercostal and abdominal muscles were held rigid, but slight movement occurred with respiration. Below a horizontal level corresponding to the second rib in front and the spines of the scapulæ behind sensation for pinprick was lost with the exception of a small area on the dorsum of each foot. Sensation for cottonwool was normal throughout ; heat and cold were appreciated above the level of the iliac crests, changes in the position of the toes were recognized and vibration was felt over the malleoli. In spite of inability to move the lower limbs at command, individual groups of muscles when tested separately acted normally. Flexion and extension of the toes on both sides were possible, there was no movement at the ankles and some flexion occurred at the knees. The knee and ankle jerks were exaggerated. It was impossible to obtain accurate readings of the plantar reflexes. Plantar stimulation resulted at times in extension of the great toe, which was, however, held in a position of partial extension owing to contraction of extensor longus hallucis.

Subsequently with direct encouragement the movements of the lower limbs improved considerably, and it was observed repeatedly that command to perform a movement resulted in contraction of both agonists and antagonists with consequent failure to perform the movement. Also to-and-fro movements occurred in the facial muscles ; and tremor associated with alternating contraction of agonists and antagonists appeared in the lower limbs. Because of these findings the patient was examined under light hypnosis on July 8, 1934. At the command to perform a movement involving the lower limbs the antagonists contracted and showed excellent power. Each of the muscle groups of the lower limbs was examined in this way and found to have normal power of contraction. When he was awake extensor longus hallucis was contracted on both sides and accurate reading of the plantar reflexes was impossible. They relaxed under light hypnosis, and plantar stimulation then produced no response. Under deep hypnosis full relaxation of the muscles of the lower limbs was secured ; and at command movements at the hip, knee and ankle were performed correctly.

Meanwhile a psychological conflict between the claims of childlike dependence on a family group and fear in facing independent life away from it was being uncovered. The former part of the conflict had been repressed. The crisis which initiated symptoms was the need to leave home and work in another part of the country to secure advancement in his occupation. With psychological exploration the physical condition of the patient was improving.

On August 16 detailed examination was made before, during and after light hypnosis. Before hypnosis there was a to-and-fro tremor in the facial muscles at rest and on movement. Voluntary and emotional movements of the face were restricted. The intercostal and abdominal muscles were held firm and very slight movement occurred with respiration. Examination of the abdominal reflexes revealed slight outward movement only towards the left upper abdominal quadrant. At command the patient flexed the right knee to 90 degrees and the left knee to beyond 90 degrees. There was normal transmission of the motor impulse to agonists. On the command to dorsiflex the right foot the muscles of the anterior compartment of the leg contracted and those of the posterior compartment relaxed. On the command to dorsiflex the left foot the muscles of the anterior compartment relaxed and those of the posterio compartment contracted. On both sides there was some contracture of extensor

longus hallucis. With this condition and slight contraction of the hamstrings, stimulation of the sole of the foot produced contraction of extensor longus hallucis and extensor longus digitorum with extension of the great toe and to a lesser extent of the other toes. When relaxation of all the muscles was secured, stimulation of the sole of the foot produced no response.

Under light hypnosis the following observations were made. On the command to bend the right knee there followed a full extension thrust of the left lower limb, contraction of the flexors of the right knee, relaxation of the extensors and a movement of flexion at the knee. The same effect was observed on the command to bend the left knee. On the command to bend up the right foot the dorsiflexors contracted and the plantar-flexors relaxed. On the command to bend up the left foot the dorsiflexors relaxed, the plantar-flexors contracted and no movement occurred. This was a lesser degree of the condition seen in the waking state. All the thoracic and abdominal muscles moved freely, whereas in the waking state they were held rigid. With slight contraction of the hamstrings and extensor longus hallucis stimulation of the sole of the foot produced extension of the great toe and of the small toes; whereas with full relaxation no response occurred.

On subsequent examinations in the waking state, to-and-fro tremor of the face was absent. Sitting up with effort was associated with a downward thrust of both feet on the bed. The command to bend either knee produced contraction of the flexors and relaxation of the extensors. Command to bend up the right foot produced contraction of the dorsiflexors and relaxation of the plantar-flexors. Command to bend up the left foot produced at first relaxation of the dorsiflexors and plantar-flexors together with contraction and fixation of the muscles above the waist. Later it produced relaxation of the dorsiflexors followed by contraction of the plantar-flexors. Later still it produced contraction of the dorsiflexors and relaxation of the plantar-flexors. On both sides, with adequate relaxation, stimulation of the sole of the foot produced no response. In the usual condition, with slight contraction of extensor longus hallucis, it produced extension of the great toe with contraction of the hamstrings and extension of the small toes. The extensor plantar reflex was closely simulated.

With uncovering and adjustment of the patient's psychological problems, together with training in voluntary movements, the physical disabilities disappeared completely.

Case III.—W.N., male, age 30 years, was admitted on August 17, 1934, in a condition of collapse. His limbs were flaccid, he was sweating freely, and his breathing was rapid and shallow. When lifted and released his upper and lower limbs fell helpless. When directed to do so he could lift his arms a few inches two or three times; their movements were tremulous and uncertain and each attempt ended with sudden cessation of effort and the limbs falling flaccid on the bed. He tried to speak, but was unable to do so. Two days later there was flaccid paralysis of the right upper and lower limbs. A few words were ejaculated in an explosive manner with long pauses between them. With encouragement he could move the fingers and the forearm a little; the movements were jerky, slow and incoordinated, and each attempt was accompanied by shallow breathing at the rate of 40 respirations a minute. Both plantar reflexes were flexor. A detailed physical examination was otherwise negative.

When seen personally six days after admission the following history was elicited. He was an only child and until the death of his mother when he was eight years old he was extremely dependent on her. From eight to 12 he was in a boarding school, failed to adjust himself to the school and to other boys, and was bullied. At another school from 12 to 14 he was happier. His father remarried when the patient was 14. From 14 to 17 the patient remained at home and resented what he regarded as interference by his stepmother's relatives. When he was 17 his father died. From

17 to 20 the patient was at sea, and was seasick most of the time. At 23 he married and left for Fiji immediately without his wife. He lived with her only during the last four months of his stay of two years in Fiji; became suspicious of her getting into debt and being friendly with other men; became very ill and was invalided home. He then separated from his wife. Thereafter he spent two years as a teacher with indifferent success, a further two years on relief works, and for the last six months had acted as agent for an insurance company. During this time he quarrelled constantly with his immediate chief. For three months he had been sleeping badly, his memory and concentration were poor, and he was irritable. The day he was admitted he had quarrelled and argued with his chief for some hours, and then suddenly lost his voice and became helpless. He claimed that three weeks before admission he had been robbed of some money he was holding for his company. During 10 years he had had five abdominal operations following indefinite abdominal discomfort.

On examination the following positive findings were recorded, all other features of the examination being negative. When told to put out his tongue he protruded it to the teeth and then retracted it suddenly. Further attempts resulted in alternating protrusion and retraction of the tongue, producing the effect of a gross antero-posterior or trombone tremor. Speech was spaced and jerky; two or three words were thrown out with obvious effort, there was a long pause, and more words were thrown out. The right upper limb lay helpless, and when lifted and released it at once fell on the bed in a flaccid condition. When told to grasp the observer's hand, contraction occurred in the muscles fixing the shoulder, elbow and wrist, but no grasp resulted. The attempt was associated with a rhythmic tremor of the limb with alternating contractions of the flexors and extensors which could be seen and felt. On cessation of effort the limb dropped at once and was found to be flaccid. When eliciting the right abdominal reflexes the midline moved abruptly, suddenly stopped and as suddenly recoiled. On stimulating the left side immediately after there was no response. The right lower limb lay helpless. When told to lift the right knee, the muscles about the hip, knee and ankle contracted, but there was no movement other than a rhythmic clonic tremor which was found on inspection to be associated with alternating contraction of opposing groups of muscles. When told to bend the right foot up there was decrease of tone in the muscles of the anterior compartment of the leg, then increase of tone and contraction of the muscles of the posterior compartment, slight plantar-flexion, and then increase of tone and contraction of muscles of the anterior group. The right plantar reflex gave no response and the left was flexor. On stimulation of the sole of the right foot there followed decrease of tone in the flexors of the toes, then some contraction and increase of tone of the extensors, but no movement of the toes occurred. The right foot was held slightly plantar-flexed with slight extension of the great toe and tension in the tendon of the extensor longus hallucis.

On September 18 there was a to-and-fro tremor in the facial muscles on beginning to speak, to smile or to show the teeth at command. In all attempts to perform movements at command in the right upper and lower limbs, there was alternating contraction of the flexors and extensors with partial fixation of the limb. The tendon of extensor longus hallucis was tense. In this condition, stimulation of the sole of the foot resulted in rapid extension of the great toe and of the small toes. Subsequent observations on this feature revealed the following. Stimulation of the sole of the left foot resulted in increase of tone and contraction of flexor longus hallucis and digitorum with flexion of all the toes. Stimulation of the sole of the right foot produced relaxation of these tendons, then increase of tone and contraction of the extensor muscles and extension of the great toe to a greater extent than of the small toes.

On October 18 there was a to-and-fro tremor in the facial muscles. On command to perform an individual movement of the right upper or lower limb there were decrease

of tone and relaxation of the agonists followed by increase of tone and contracton of the antagonists, a movement in the direction opposite to that commanded, stretch of the agonists and increase of tone and resistance of the agonists. Early in December the motor phenomena had disappeared with the exception of a tremor in the facial muscles.

Case IV.—G.S., male, age 31 years, was referred on June 23, 1934, complaining of inability to straighten the left arm at the elbow. Four months before boiling tar had splashed on the front of the left elbow. When he returned to work one week after the accident with the skin healing, he found that he could not straighten the left arm at the elbow. This disability had become worse during local treatment to the arm.

He was apprehensive and showed tremor of the eyelids. The left arm was held with the elbow flexed at 135 degrees. With encouragement he could extend the forearm a little further, but when he did so the flexors contracted and further extension became impossible. At command and with passive movements the flexors relaxed somewhat; then the flexors contracted again and there followed a to-and-fro tremor associated with alternating contraction of the flexors and extensors. The remainder of the physical examination was negative. Until the age of five years he had been at home. His father was often cruel to his mother. The patient was afraid of his father and sought his mother's protection. At four he was separated from both father and mother and sent to an orphanage, where he remained until he was sixteen. From 16 to 31 he had wandered from one occupation to another. Throughout life his approach to every situation and problem had been characterized by a struggle between his urge to deal with it and fear.

Case V.—N.S., female, age 32 years, was referred on June 16, 1934, with the complaint that she was unable to use the left hand. Six days before she had been sitting in a cinema with the left leg crossed over the right knee and her left hand in her lap. She felt pins and needles in the left upper and lower limbs. When she got up to leave her left lower limb moved normally, but the left hand hung loosely at the wrist. For six months she had fatigued easily. There had been no previous illnesses. She had been married 13 years, had one child 11 years old, and thereafter had practised c. interruptus. Apart from inability to extend the left hand at the wrist there were no physical signs.

Subsequent examination showed the following. When the left hand was held on the same level as the forearm some extension occurred at the wrist. On the command to extend the left wrist the extensors relaxed and became helpless, the flexors then contracted firmly and became rigid.

She was fourth of a family of five and was strongly dependent on her mother until the death of the latter when the patient was 17. She married at 19 and had a child 18 months later. Three years before she was seen her husband had an accident in which he lost much of his vision. Thereafter he had been employed regularly on light work at smaller wages and the fear of pregnancy which the patient had had since the birth of her child became more acute. With the loss of his employment four months before the patient worried a great deal, was still more afraid of pregnancy and became frigid. With the onset of the drop-wrist her worries ceased. The personal situation was explored, a superficial adjustment obtained, and on May 25, 1934, the left upper limb was normal.

Case VI.—F.G., male, age 55 years, was seen on August 10, 1934, when he complained of being unable to grip with the left hand and of numbness and pins and needles in the left hand of three months' duration. Three months before he was shovelling coal from a railway truck with his left hand on the handle of the shovel and his right hand at the end of the shaft. The shovel struck a bolt in the floor of the truck. Pain was felt in the left hand and forearm. He tried to use the shovel

again immediately and found the left hand fall helpless at the side. The left hand swelled and became congested, but these effects soon subsided. His domestic life was unhappy and he was ruled constantly by an overbearing wife.

On examination the left hand and forearm were held rigid. On the command to flex the left elbow both freely and against resistance the extensors of the elbow contracted. On the command to extend the left elbow the flexors contracted. On the command to flex or extend the left wrist there was contraction of the flexors and extensors at the elbow and in the forearm, with a to-and-fro tremor of the whole limb characterized by alternating contraction of flexors and extensors. In neither case did any movement occur at the wrist. With the command to flex or extend the fingers there was the same result and no movement of the fingers occurred. Sensation for cottonwool and pinprick was lost to a horizontal level 3 inches above the elbow, the vibration of a tuning fork at the wrist was described as ' something there,' changes in position of the fingers were not recognized, and objects placed in the palm of the hand were not recognized. In all other respects physical examination was negative. Examination on August 24, 1934, showed the following. On the command to grip with the left hand the flexors and extensors of the fingers became atonic and contraction of the flexors and extensors of the elbow and wrist occurred. On the command to grip both right and left hands, the right hand gripped normally and flexion of the left fingers and thumb occurred to about 15 degrees. On the command to grip with the left hand the flexors and extensors of the fingers became atonic. Then with the wrist supported the flexors and extensors of the fingers were stretched alternately. At first there was no resistance in these muscles, then tone and resistance gradually increased, and finally definite contraction with resistance to passive movements occurred.

Case VII.—A man, age 28 years, was seized with acute pain in the right side of the abdomen and admitted to hospital the same evening. On admission he complained of severe pain in the right lower abdomen from above the iliac crest to the right groin. Notes made at the time recorded a rapid pulse rate, limitation of respiratory movements of the abdomen and rigidity of the abdominal muscles on palpation. Laparotomy that night failed to reveal any abnormality in the abdomen. The rigidity subsided, but the pain persisted in a less acute form. The urine was normal and a cystoscopic examination was negative. He was seen and examined personally three weeks later. He still complained of pain in the right side of the abdomen and of burning at the end of the penis. Examination showed apprehension, some proptosis of the eyeballs with lagging of the upper eyelids on downward deviation of the eyeballs, fullness of the thyroid gland, exaggeration of tendon reflexes in upper and lower limbs, an excessive response to sensory stimuli, tenderness on palpation of the right side of the abdomen and right loin, and a to-and-fro movement of tremor in the facial muscles. Exploration of his personal history showed excessive mother dependence persisting into adult life. His first experience associated with abnormal fear was at 10 years of age. He was sitting in a car by his father when the latter collided with and killed a man. When he himself began to drive a car he found that when an awkward situation arose he ' became paralyzed with fear ' and was unable to take rapid action to avoid a collision. He had many accidents. Two years before admission he collided with and killed a man, and underwent trial for manslaughter. The same ' paralysis with fear ' had occurred at the time of the accident. At the same time he was subjected to uncomfortable pressure above the right iliac crest by the edge of the front seat of the car. He had to leave home, and after being away for three months began to have discomfort above the right iliac crest and in the right side of the abdomen. This pain persisted, and twelve months later his appendix was removed. It was normal. Before his admission to hospital he had been living with a sister and her husband, and had found some comfort in the attention the former gave him.

On the day of admission criticism of his helplessness and attitude of dependence by his brother-in-law and the suggestion that he should leave and fend for himself was followed after a short interval by acute pain in the abdomen.

REFERENCES

[1] ALLEN, I. M., *Jour. Neurol. and Psychopathol.*, 1931, **12**, 24.

[2] FOX, E. L., *Brit. Med. Jour.*, 1922, **1**, 513.

[3] CREED, R. S., DENNY-BROWN, D. E., ECCLES, J. C., LIDDELL, E. G. T., and SHERRINGTON, C. S., *Reflex Activity of the Spinal Cord*, 1932.

[4] WILSON, S. A. KINNIER, *Proc. Roy. Soc. Med.*, 1930, **24**, 173.

Dr. C. E. Beevor's Croonian Lectures of 1904 and a paper by Graham Brown and R. M. Stewart, which are not available to me for direct reference, are referred to in Dr. Kinnier Wilson's paper.

THE BRAIN OF THE MENTAL DEFECTIVE: PART 3. THE WIDTH OF THE CONVOLUTIONS IN THE NORMAL AND DEFECTIVE PERSON

By

W. R. ASHBY AND R. M. STEWART, LEAVESDEN

INFOLDING of the cerebral cortex being nature's device for increasing the superficial area of cortical grey matter without a corresponding enlargement of the skull, it is perhaps not illogical to assume that individuals whose intellectual attainments are of a high order will possess a cortical pattern more intricately convoluted than that of the ordinary person, while those with a mental endowment much below the normal will display a convolutional pattern of diminished complexity.

It must be confessed, however, that the documentary evidence for this view is of a somewhat conflicting character. Rudolf Wagner,[1] who in 1860 examined the brains of three eminent scholars, including that of Gauss, the mathematician, was unable to draw any definite conclusion. The small brain of the distinguished French writer Anatole France [2] showed a very unusual degree of convolutional complexity, the individual gyri being sharply defined, well formed and pressed tightly together, the whole brain being acclaimed a piece of real goldsmith's work. On the other hand, the brain of a distinguished American philosopher which was studied by Wilder [3] displayed convolutions so simple in character as to give it an almost infantile appearance. It appears, therefore, that the brains of the élite present no constant feature in their convolutional pattern: in one the fissuration may be complex and in another simple. To this subject a further communication has recently been made by Addison and Donaldson [4] in a paper entitled 'On the area of the sunken cerebral cortex as determined from the length and depth of selected sulci in three classes of human brains: scholars, hospital whites, and hospital negroes.' Having ascertained that the area of sunken cortex is sufficiently well correlated with that of the exposed surface to make the measurements of the former indicators of the entire cortical surface, they proceeded to measure the area of the sunken cerebral cortex in each of four different lobes—frontal, parietal, occipital and temporal. It was found that the data from the hospital whites, when compared with the date from the negroes, gave graphs nearly identical, i.e. the allotment of sunken cortex to the several lobes was approximately constant as between the races compared and, except in the

temporal area, the superior mental performance of the scholars was not associated with any marked variation in the extent of the four areas.

As regards the mentally defective person, although the statement is often made that the cerebral convolutions are of markedly diminished complexity, and although a smooth pachygyric brain is not infrequently seen in idiocy, no serious attempt appears to have been made to study the cortical surface by accurate objective methods on a large and representative series of cases. Southard and his co-workers [5] have something to say on the convolution pattern in their study of a series of 20 aments' brains, but their conclusion that the mental ratings of their patients corresponded fairly closely to the estimated complexity of convolutional pattern must be accepted with reserve, since complexity was assessed simply by naked-eye inspection, a

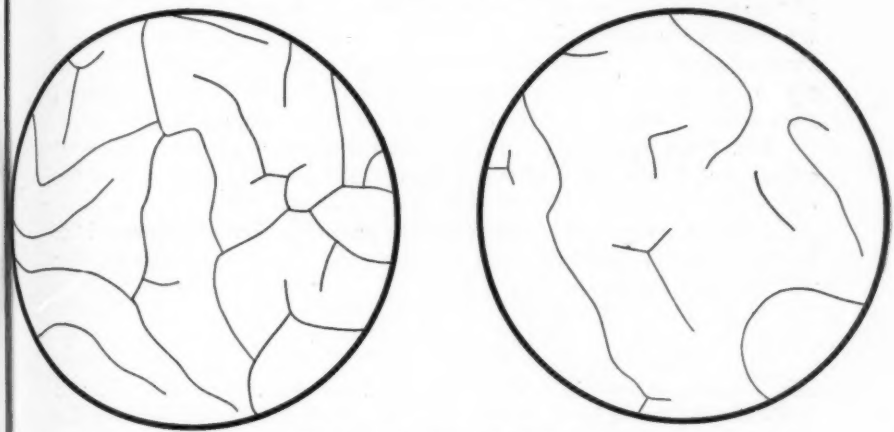

FIG. 1.—Showing the general appearance of the drawings of the surface convolutions. The area of the circle was constant. The length of lines appearing in the circle was measured in each observation.

method which cannot be regarded as other than impressionistic in character. It is obvious that visual inspection unaided by other methods can afford but the roughest guide, and a brain pattern which one observer might describe as simple might quite well be passed by another as within normal limits.

With these considerations in mind the present study of the convolutional pattern of the aments' brain has been undertaken with the object of securing measurements whose significance could be evaluated in as objective a manner as possible.

METHOD

To measure the complexity in any given region we decided to take an area of standard size and then measure the total length of sulci appearing in this area (see fig. 1). It is clear that the total length of sulci occurring in

this area will provide a measure of the complexity of the convolutions. Further, if we calculate

$$\frac{\text{area examined}}{\text{total length of sulci in the area}}$$

we obtain a measure of the *mean width of the convolutions*. Since this quantity is simple and easily understood, we have decided to give our results in this form. It should be noted that 'mean width' and 'complexity' vary inversely, in that great complexity means small width. This point is apt to cause confusion unless borne in mind.

The actual details of the method will now be given.

A sheet of tin with a circular hole 5 cm. in diameter cut in it was placed in the epidiascope with the brain so arranged under the hole that an enlarged picture of the cortical area showing through the hole was projected through the epidiascope and reflected by a mirror on to the table. The method is similar to that used by us [6] for the corpus callosum. In this way there was obtained an enlarged picture of any given area of the surface convolutions and the sulci lying within the circle could then be copied on to paper.

Fig. 1 shows the most complex and the simplest patterns which we encountered in our series of 62 brains, and the general appearance of the drawings. The actual drawings were, of course, much larger.

In order to obtain the mean width of the convolutions we measured the length of sulci visible in the given area by measuring them on the drawing with a map-measurer and then calculating

$$\frac{\text{area covered}}{\text{total length of sulci}}$$

This gives the mean width of the magnified drawings. The true width in the brain was found by dividing by the magnification, which in our series was $\times$ 3·71 diameters.

The actual experimental error of this method was tested on our series and will be given later. Meanwhile there are some points to be noted.

1. *Areas Measured.*—Different regions tend to have different mean widths of convolutions. Consequently the regions examined must be fixed. In our series we measured three regions: (I) medial frontal surface, (II) the centre of the parietal lobe, and (III) the medial surface of the occipital lobe. The regions are indicated in fig. 2.

2. *Pia Mater.*—With the membranes present it was impossible to follow the sulci with any certainty, and therefore in all cases the pia-arachnoid was removed.

3. *Depths of the Sulci.*—The method, of course, does not examine the depths of the sulci. This, however, does not appear to be a very serious criticism and need not vitiate our conclusions as long as it is carefully remembered that our work deals only with the surface convolutions.

4. *Microgyria.*—This condition, in which gross disturbance of the normal

cortical lamination occurs, is probably quite different from the ordinary small variations in width of convolutions, and its presence in any of the brains would give such an extreme figure as to distort the whole picture. In none of the brains examined, however, was there any evidence of this condition.

5. *Personal Equation.*—The method is undoubtedly dependent on the personal equation of the particular observer. For this reason it is essential that the whole of the drawings should be done by one person, and that the same person should also examine a series of normal brains to act as his own normal controls. Further it should be noted that it is not permissible in using this method to compare one worker's figures with those of another worker.

Although the method is subject to these somewhat severe restrictions, yet it remains perfectly valid for our purpose, since it is permissible to

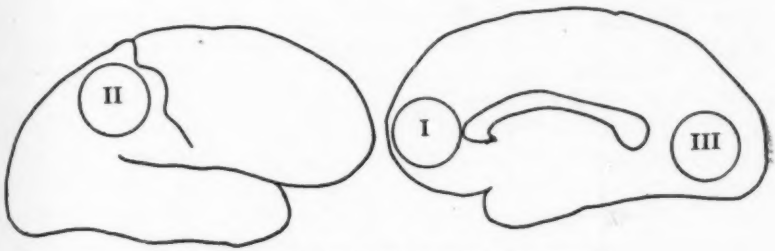

FIG. 2.—Diagram showing the three regions measured.

compare two groups of brains measured by the same person and at the same time.

6. *Error due to Curvature.*—The frontal and parietal regions measured are slightly curved, and this may introduce some error, since when the image is projected we are treating it as flat.

The size of this error for a given degree of curvature may be best investigated mathematically. If the true mean width of the convolutions is unity, then the apparent mean width will be

$$\frac{\pi\,\phi^2\cos^2\frac{\phi}{2}}{4\int_0^{\phi}\left(\phi\int_0^{\pi}\sqrt{1-\sin^2\phi\,.\,\sin^2\theta}\,.\,d\theta\right)d\phi}$$

where ϕ is half the angle subtended at the centre of the sphere by the spherical cap. Since, in our method, the diameter of the hole in the tin plate was 50 mm., we may express the curvature by measuring the height (h) which the curved surface of the brain projects through the hole. Fig. 3 shows the percentage error due to curvature for varying amounts of projection (h).

None of the brains showed curvature sufficient to bring them through

the hole by more than about 5 mm. Consequently the error due to curvature will not exceed 2 to 3 per cent. In most cases it will be less than this. The smallness of the effect of curvature for small curvatures is due to the fact that there are really two factors at work which almost exactly balance each other for small degrees of curvature.

7. *Error in Measuring the Lines.*—The map-measurer was tested and was found to be highly accurate, the error being barely measurable. The area of the hole in the tin plate was measured directly with Amsler's planimeter.

8. *Accuracy of the Method as a Whole.*—Each area in each brain was measured twice, giving 372 measurements in all. The advantage of measuring

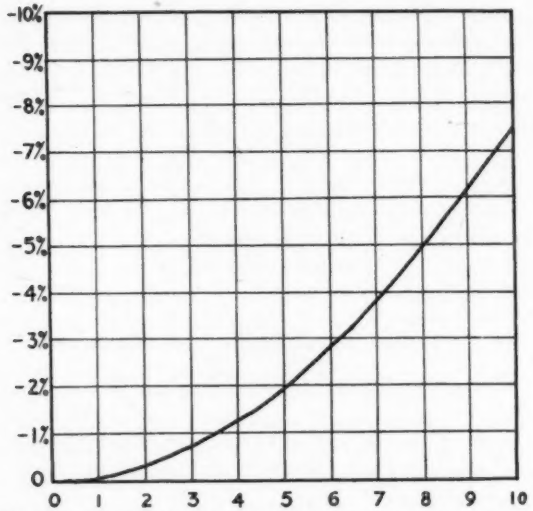

FIG. 3.—Shows the percentage error introduced by curvature when the brain projects *h* mm. through the 50-mm. hole.

each area twice is not only that it gives increased accuracy, but also that it allows us to estimate the total experimental error. We have in this series 186 pairs of measurements. Were there no error, each pair of measurements would give identical results. In practice they do not come out identically the same and the differences enable us to estimate the experimental error.

The most useful way of considering the error is to calculate

$$p = \frac{\text{experimental variance}}{\text{total variance between patients}}$$

then 100 p gives us the percentage of information wasted by experimental error. Since each case examined provides a definite amount of information, we may express the experimental accuracy by giving the theoretical number of patients which, measured with infinite accuracy, would be equivalent to

our series measured with our experimental error. We find, for the three areas, that the equivalent number of patients is :

Frontal area	58·5
Parietal area	55·7
Occipital area	49·9

With these figures, and with the distribution of mental ages in our series, it may be shown that if mental age is responsible for more than 11 per cent. of the variance in mean width of convolutions, then we shall be sure of getting a significant correlation. This figure (11 per cent.) shows (*a*) that our series contains a sufficient number of cases to be statistically valid, and (*b*) that the experimental error is sufficiently small.

9. *The Results.*—We may now give the results (Table I). Column 1 gives the patient's reference number. Column 2 gives the patient's mental age (years). Column 3 gives the mean width of the convolutions (frontal area) (in millimetres). Column 4 gives the mean width of the convolutions (parietal area) (mm.). Column 5 gives the mean width of the convolutions (occipital area) (mm.). Column 6 gives the mean width of the convolutions (all three areas averaged together) (mm.). Column 7 gives the figures in Column 6 divided by the cube root of the weight of the cerebrum of each patient. In Columns 3, 4 and 5 the figure given is the mean of two measurements.

TABLE I

(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	1	8·1	7·3	7·6	7·7	0·72
2	1	7·1	6·1	6·9	6·7	0·66
3	1	7·1	6·2	6·8	6·7	0·72
4	3	8·3	5·8	6·8	7·0	0·71
6	4	7·5	7·6	8·9	8·0	0·79
7	5	7·3	7·2	7·7	7·4	0·73
8	5	9·8	7·8	9·4	9·0	0·86
9	7	6·7	6·3	7·6	6·9	0·72
10	8	7·4	7·8	7·8	7·7	0·81
11	9	7·3	7·4	7·6	7·4	0·80
12	1	6·7	6·8	7·8	7·1	0·73
13	5	7·7	7·0	7·8	7·5	0·74
15	7	7·8	7·2	8·0	7·7	0·75
16	3	6·7	6·6	7·2	6·8	0·67
18	2	7·5	6·2	7·9	7·2	0·69
19	5	7·0	6·3	7·1	6·8	0·73
20	5	7·7	7·3	7·3	7·4	0·72
22	5	7·6	7·3	7·6	7·5	0·77
23	3	7·5	6·8	6·3	6·9	0·70
24	3	7·3	7·1	8·1	7·5	0·71
25	5	6·4	6·9	7·2	6·8	0·65

(1)	(2)	(3)	(4)	(5)	(6)	(7)
26	5	6·6	7·5	7·4	7·2	0·67
27	6	6·9	7·1	7·2	7·1	0·72
28	8	7·7	7·4	7·4	7·5	0·74
29	4	6·7	7·1	7·1	7·0	0·67
30	2	8·3	7·9	8·8	8·3	0·92
31	2	7·6	7·7	7·6	7·6	0·76
32	3	8·1	7·6	8·0	7·9	0·75
34	9	7·6	7·2	6·9	7·2	0·71
35	3	6·6	7·0	7·6	7·1	0·75
36	3	9·4	7·2	9·1	8·6	0·86
37	4	8·5	7·9	8·5	8·3	0·82
38	0	8·5	7·5	8·7	8·2	0·76
39	1	6·6	7·3	6·7	6·9	0·62
41	4	6·9	6·9	7·7	7·2	0·71
42	2	9·1	9·1	8·6	8·9	0·84
43	2	7·0	7·9	7·6	7·5	0·72
44	6	7·7	8·5	8·0	8·1	0·82
45	7	8·3	8·6	8·3	8·4	0·79
46	3	9·7	8·5	9·3	9·2	0·93
47	5	7·2	7·3	6·8	7·1	0·73
49	3	6·9	7·6	7·7	7·4	0·75
50	6	6·8	7·2	7·9	7·3	0·74
51	3	8·9	7·1	7·5	7·8	0·81
52	8	9·7	8·2	9·4	9·1	0·93
53	1	8·3	7·5	8·8	8·2	0·82
54	4	7·8	8·1	7·9	7·9	0·81
55	6	8·1	7·6	9·9	8·5	0·85
56	1	6·6	6·4	7·1	6·7	0·66
57	3	8·3	7·3	8·8	8·1	0·80
58	0	8·0	6·8	8·2	7·7	0·76
59	1	7·5	7·0	8·2	7·6	0·69
60	9	7·5	7·7	9·0	8·1	0·79
62	0	8·3	8·0	9·3	8·5	0·87
63	14	7·3	7·6	8·5	7·8	0·76
65	14	8·3	7·5	7·7	7·8	0·76
66	14	7·5	6·6	8·0	7·4	0·76
67	14	7·6	7·3	8·0	7·6	0·72
68	14	7·7	6·8	10·1	8·2	0·78
69	14	7·5	7·5	8·1	7·7	0·70
70	14	7·6	7·5	7·9	7·7	0·72
71	14	7·7	8·7	7·8	8·1	0·76

The sole point in which we are interested is to see whether mean width of convolution shows any relationship to intelligence. We may investigate this point first by plotting each patient's average width of convolution (averaged from all three areas) against his mental age. The results are shown in fig. 4. We may state at once that when each area is plotted separately the

graphs are similar to fig. 4, so that the individual areas need not be given separately.

With regard to fig. 4 there are several points of interest. The first is that the commonly accepted statement that idiots have broad convolutions cannot be substantiated. We may note that no less than 21 out of the 54 defectives have convolutions narrower than those of the narrowest normal. The brain which actually had the narrowest convolutions of all was that of an idiot of mental age one year.

To test whether there is any tendency to broadness or narrowness in the

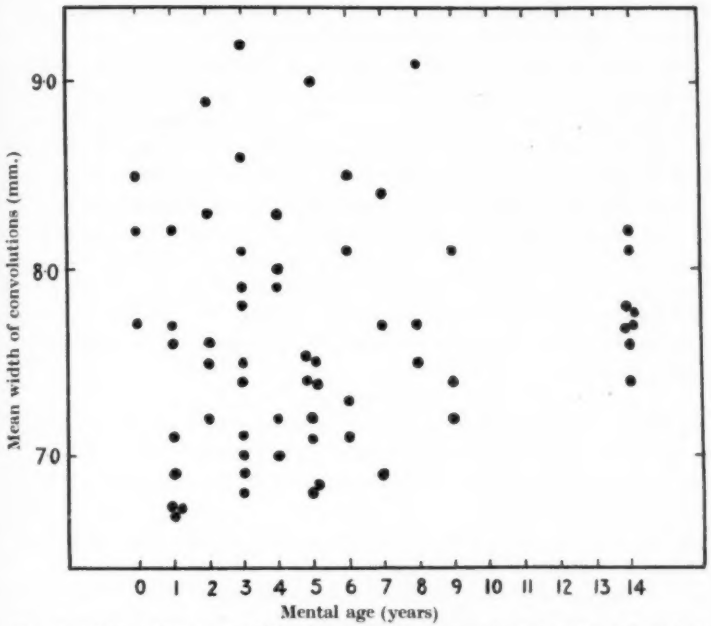

FIG. 4.—Shows the mean width of convolutions for each patient plotted against his mental age. Each dot represents one patient.

defectives' convolutions, we have also calculated the correlations between mental age and the mean widths given in Columns 3 to 6. None of the correlations proved statistically significant. One other test may be applied. If we find the average of the eight normals (= 7·79 mm.) and count the numbers of defectives who are over and under this level, we find that 19 of them have mean convolution-width greater than the average normal, while 35 have a smaller width. These two numbers (19 and 35) are not equal, but the difference might be due to random sampling. Using the χ^2 test we find that P = 0·03, suggesting fairly strongly that there is a real tendency for the

defectives' convolutions to be slightly *narrower* than the average normal. This, it should be noticed, is just the opposite to the commonly accepted view.

So far, however, we have been dealing simply with the absolute width of the convolutions. But it is known that there is a tendency for the lower grade defectives to have slightly smaller brains. If a brain is diminished in size, and if the convolution *pattern* remains the same, then the convolution-width will be diminished. To obtain the relative width of the convolutions, we divide the actual width by the cube root of the weight of the cerebrum. The results are given in Column 7 of Table I. This column gives the width which would have been obtained if each brain had been magnified or diminished so that all brains were adjusted to the same size.

Testing the results as before, we find now that the numbers of defectives over and under the average normal are 27 and 27, i.e. the previous difference has disappeared. This disappearance of the previous bias suggests that *on the average the defectives' convolution-width is much the same as that of the normal, a slight reduction appearing in those brains which are small all over.*

A second point to note in fig. 4 is that while the eight normals are grouped fairly closely together, the defectives show a much wider scatter—some having very broad convolutions, and some having very narrow convolutions. We have noted this feature in a number of investigations and it appears to be a fairly general characteristic of defectives' brains. This feature also appears just as clearly when the relative widths are graphed. Its significance is at present uncertain.

SUMMARY

1. We have investigated the question whether mental defectives tend to have convolutions broader or narrower than the normal person.

2. A method has been devised and tested for measuring the mean convolution width.

3. The experimental error of the method has been tested and has been shown to be sufficiently small.

4. The mean convolution width has been measured in 62 brains, 54 being from defectives of known mental age and eight from normal adults. Three areas were measured on each brain. Each area was measured twice.

5. We find that our results are quite incompatible with the view that defectives tend to have broad convolutions. On the contrary, the data suggest that, if anything, there is a tendency for the convolutions to be a little *narrower* in the defective. On finding the width relative to the size of the cerebrum, however, this tendency disappears. On the average, the defectives' convolutions appear to be of about the same width as the normals, a slight reduction appearing in those brains which are small all over.

6. The outstanding characteristic of the defectives' convolutions would appear to be that the brain of one defective varies much more from another defective's brain than do the normals from each other.

REFERENCES

[1] WAGNER, R., quoted by H. H. Donaldson in *Amer. Jour. Psychiat.*, 1932, **12**, 197.
[2] KEITH, *Brit. Med. Jour.*, 1927, **2**, 1048.
[3] WILDER, B. G., *Jour. Compar. Neurol.*, 1895, **5**, 124.
[4] ADDISON, W. H. F., and DONALDSON, H. H., *Jour. Compar. Neurol.*, 1933, **57**, 429.
[5] FERNALD, SOUTHARD and TAFT, *Waverley Researches in the Pathology of the Feeble-minded*, 1918.
[6] ASHBY, W. R., and STEWART, R. M., *J. Neurol. and Psychopath.*, 1934, **14**, 217.

THE RESPIRATORY RHYTHM IN NORMAL AND PSYCHOTIC SUBJECTS

By

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In a previous article [6] it was found that schizophrenic patients breathed on the average more shallowly and more rapidly than normal subjects. In the present study an attempt is made to examine the respiratory rhythm in normal subjects and then to compare it with that found in individuals suffering from schizophrenia, the manic-depressive psychosis and epilepsy.

The apparatus used to take the records of these patients was that described by Golla and Antonovitch.[2] This consists essentially of a wooden box with a removable lid and front piece. The subject for experiment sits in the box and only his head projects through the roof. The box is air-tight and communicates with a recording plethysmograph by means of a wide tube. In this way respiratory movements can be recorded. When this instrument is used, the subject need have nothing strapped round his chest or abdomen. He is unaware that his respiration is being examined, and therefore the possibility of conscious interference with rhythm is eliminated.

The respiratory movements as well as being concerned with oxygen and carbon dioxide exchange have, in the phylogenetic development of man, become closely associated with the higher centres of the brain, more especially those connected with speech. It has long been known that changes in thought are accompanied by changes in respiration.

This subject has been studied by various workers since the time of Mosso, and it is worth while recapitulating the conclusions arrived at by succeeding observers.

SUMMARY OF PREVIOUS LITERATURE ON THE RHYTHM OF RESPIRATION

Towards the beginning of this century considerable interest was taken in the character of the respiratory curve. The chief object in view was to ascertain whether certain states of mind were accompanied by characteristic types of respiratory record (see Table I).

Several contributors to Wundt's *Philosophische Studien* and later *Psychologische Studien* discussed this problem. An article by Rehwoldt,[8] for instance, illustrates the thoroughness of some of these investigators. He applied six bands round the subject's thorax and abdomen. Attempts were made to ascertain if there were characteristic curves in such conditions as

hilariousness, æsthetic pleasure, bliss, or enthusiasm ; also in anger, depression rage, pain and tension. The results of these investigations were for the most part negative. He concluded that affects could be divided into three classes :— (1) Restful affects. (2) Affects with excitement. (3) Tension. Diminution in the height of the curve occurred in (1) and (3), increase in (2). The rate of respiration was greater in (2) than in the other two conditions.

TABLE I. SHOWING SUPPOSED EFFECTS OF MENTAL STATES ON RESPIRATION

Author	Pleasant sensation	Unpleasant sensation	Sudden emotional reaction	Voluntary attention	Reverie
Mosso	—	—	—	slow	fast, deep and irregular
Rehwoldt	—	—	fast and deep	—	—
Lehmann	deep and regular	deep irregular	— —	— —	— —
Mentz	slow	fast	—	—	—
Zoneff and Meumann	shallow and fast	deep and slow	— —	fast and shallow (but great individual differences)	— —
Angell and Thomson	little affected	little affected	irregular	regular generally : irregular when tendency to vocalise	—

Lehmann [3] was especially interested in the effect of pleasant and unpleasant impressions. He believed that the former increased the depth of respiration, and that strong unpleasant impressions were accompanied by several deep respiratory movements. Mentz [4] concluded that pleasant feelings caused a slowing of respiration while unpleasant quickened it. Zoneff and Meumann [10] made an exhaustive study in normal individuals, employing various stimuli—optic, acoustic, gustatory, cutaneous and psychic (arithmetical problems and space conceptions) ; and studied at the same time the effects of voluntary attention and pleasant and unpleasant impressions on the respiration. They found that there were great individual differences but that voluntary attention usually caused increase in rate but decrease in depth, sometimes amounting to inhibition of respiration. They believed that pleasant sensations caused shallowing and acceleration, but unpleasant sensations deepening and slowing. Reference to Table I will show how conflicting the results arrived at by these investigators were.

In England, Angell and Thomson (1899) [1] made a contribution to the subject. They refer to the work of the physiologist Mosso who had previously given much of his attention to this subject. He studied chiefly the effects of emotion and found that it was ' impossible to make any satisfactory classification of breathing types as connected with mental activity or emotion.' Angell and Thomson themselves came to very reasonable conclusions. They found that respiration tended to be regular where the organism was undisturbed by changes in the environment, that is, so long as the subject's equilibrium was maintained. In voluntary attention the rhythm was generally regular. They mentioned incidentally that where there was a ' tendency to pronounce words '—as when the subject was asked to remember nonsense syllables—the breathing became irregular.

An important contribution to the subject was made by F. Peterson and C. G. Jung [7] in 1908. They studied the pneumographic curve in conjunction with the socalled psychogalvanometer. Among other things they studied the characteristics of the normal curve, and the effect on it of emotional stimuli and also of attention. They also studied the same phenomena in schizophrenics. Their material, however, was small compared with that about to be described in this investigation. In the article referred to they made some observations which are of interest in relation to the present study.

' It is altogether probable that there are more inexplicable influences at work in relation to the pneumographic curve than we are at present able to comprehend. There are many respiratory fluctuations which have nothing to do with the emotions, but are the result of physical or intellectual processes, together with the enforced quiet of the body at rest, the test person, with the disposition to speak, etc.'

' Again, when the emotions are very labile, and show the most marked excursions in the galvanometer curve, the respiratory curve is often regular and even. On the other hand in instances both normal and pathological, where the galvanometer curve is marked by little fluctuation, or even by none, as in some cases of catatonia, there will often be most decided variations in the pneumographic curve. There does not seem to be the intimate and deep relationship between the respiratory function and unconscious emotions that exists between the sweat glandular system (which influences the psychogalvanometer) and the emotions. . . . Respiration is an instrument of consciousness. You can control it voluntarily while you cannot control the galvanometer curve. The respiratory innervation is closely associated with speech innervation, anatomically and functionally, and the physical connection in the brain is, perhaps, one of the closest and earliest ' (*loc. cit.*, pp. 173–175).

One of the most important advances in the above paper was the observation that there are irregularities in the respiratory curve which have not to do primarily with emotion ; also that there is a close connexion between the

intellectual functions, especially the function of speech, and the respiratory function.

These facts were further elucidated by Golla and Antonovitch [2] in 1931. These observers examined 67 normal subjects with reference to the regularity of respiratory rhythm. Neglecting the emotional factor, which they believed to be easily recognizable when it occurred, they directed their attention to an examination of the mental content of these individuals. They were at once struck by a correlation between visual imagery and regular breathing on the one hand, and auditory imagery and irregular breathing (with a tendency to vocalize) on the other. Of the 67, 34 were classed as regular breathers. All except one had considered themselves to use predominantly visual imagery. The remaining one had said he used predominantly auditory imagery. Thirty-two subjects showed an irregular rhythm, and of these 28 had been assessed by their answers as using predominantly auditory imagery, the remaining four being classed as visualists. One had been doubtful.

In discussing the significance of the two types of respiratory rhythm, these writers point out that in their experiments irregular rhythm frequently became regular when a problem was set, the solution of which required purely visual imagery. They considered that irregular respiration was caused by the use of a kind of internal speech. They added, however, that it would be wrong to assume that such irregularity of rhythm is in any sense a point-to-point representation of the actual respiratory disturbance that would take place if the auditory images were to be translated into spoken words. If this were so, such images could only occur, as in speech, during the expiratory phase, whereas anyone belonging to the auditory type is conscious that the images arise uninterruptedly both during expiration and inspiration. The irregularity is of a less definite character, diaphragm and thoracic, as well as laryngeal, muscles helping to cause it.

SCOPE OF THE PRESENT ENQUIRY

The object of the present inquiry has been to find out with the improved apparatus if there is any particular mental process which in normal subjects gives rise to a special type of respiratory tracing. The results of the investigations just quoted, for instance, would seem to indicate that auditory imagery with a tendency to vocalization gives rise to an irregular type of respiration.

Secondly, is there any feature which is more frequently found, or solely found, in the respiratory tracing of a psychotic as compared to a normal individual ?

Thirdly, are the respiratory reactions of psychotic subjects to various stimuli different from those of normal subjects ?

In what follows an account is given of the results obtained, and also a discussion of how far the questions stated above are answered.

RESPIRATORY RHYTHM IN NORMAL SUBJECTS

In the present series 65 normal subjects were tested. These were nearly all members of the staffs of the Maudsley and Colney Hatch Mental Hospitals, who kindly consented to co-operate in this work. The first

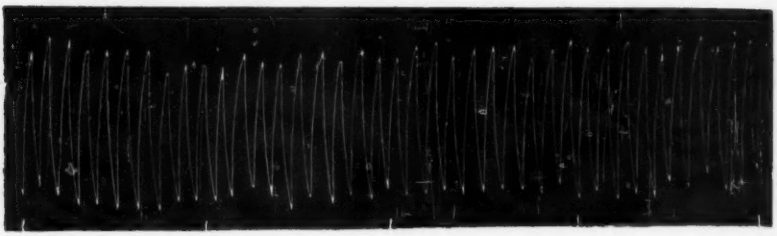


FIG. 1.—Example of regular breathing. Time signal 30 seconds. (In all these figures upstroke represents inspiration.)

problem to be examined in each of these experiments was whether the individuals showed either predominantly regular or irregular rhythm (figs. 1 and 2).

Of the 65 normal subjects, 45 males and 20 females, 32 (22 men and 10

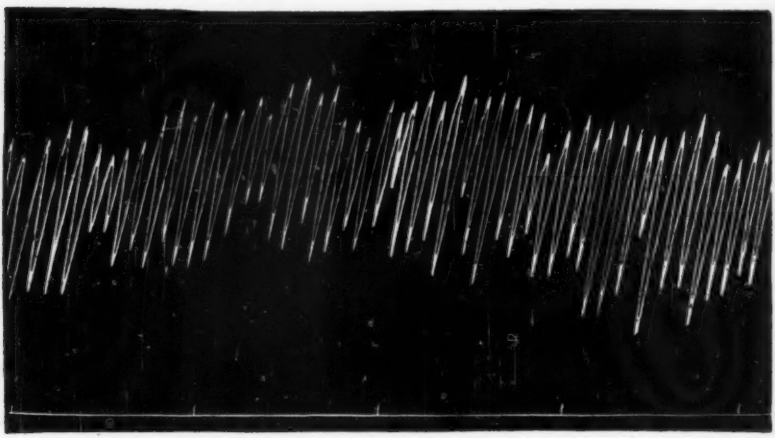


FIG. 2.—Irregular breathing. Time signal 30 seconds.

women) were regular breathers, while 33 (23 men and 10 women) were irregular (Table II). These figures corresponded roughly to the figures of Golla and Antonovitch quoted above, who found that of 67 normal cases, 54·5 per cent. were regular and 45·5 per cent. irregular.

TABLE II. RELATION OF REGULAR OR IRREGULAR RHYTHM TO TYPE OF IMAGERY (VISUAL OR AUDITORY)

	Regular	Irregular	Visual	Auditory	Regular and visual	Percentage of regular breathers who are visualists	Irregular and auditory	Percentage of irregular breathers who are auditories
Men	22	23	23	22	16	72·8	16	69·6
Women	10	10	10	10	8	80	8	80
Both	32	33	33	32	24	75	24	72·8

An attempt was made to eliminate from the outset any physical causes of irregularity. Any tongue or lip movements in the nature of a tic caused irregularity. It was possible, however, for the observer to stand at the side of the subject and watch for any movement of the lips or tongue. If any such were seen, the record was discarded. Another factor which influenced the rhythm was catarrh of the respiratory passages. All the subjects were free from this at the time of examination. Any marked restlessness on the part of the individual was apt to cause a characteristic kind of irregularity, although small movements failed to interfere with the predominant rhythm. As might be expected, the respiratory curves were also affected by any emotion of even moderate degree. The whole subject of the effect of emotion on respiration is a wide one, as has been indicated, and it is not proposed to discuss it here. The nature of the change caused by emotion, whether to deeper or shallower breathing, depends on a variety of causes, which have been studied by the workers quoted above. In what follows, it is only pointed out that the irregularity caused by emotion is of a different type from that under discussion. Where the respiration was influenced by emotion, it would suddenly change and then return to normal after a number of breaths. For a record where the phenomenon was frequent, the term 'labile' seemed applicable. The true irregularity of rhythm which is the present subject for study is something different. The irregularity is rather from one respiration to the next, not from series to series (fig. 2). The change of respiration to deeper or shallower for a while following emotion might characterize either an otherwise regular or irregular record. It was impossible to tell beforehand which individual would be regular and which irregular, merely by noticing the degree of 'nervousness.' Some cases of anxiety neurosis were very regular, and also not labile, while some apparently apathetic subjects were irregular.

Neglecting therefore the question of emotion, the writer proceeded to test the degree of auditory imagery with its tendency to vocalize, in these subjects. He asked a number of individuals to think out a problem while sitting in the apparatus. They did not know during the test that their respiration was being examined. The inquisitive were merely told that the apparatus had in some way to do with metabolism. The first problem was

of such a kind that the subject would most easily solve it by using not auditory but visual imagery. He was asked first to look at a sheet of paper which showed each of the capital letters of the alphabet. He was then asked to picture each letter as he would see it in a mirror. He was told that at the end of the experiment he would be asked which of the letters looked the same in the mirror as when looked at direct. This ensured that the subject would concentrate as thoroughly as possible.

In fact, A H I M T U V W X Y appear the same in a mirror as when looked at direct. If an individual, for instance, included N S and Z he was considered to have a bad capacity for visual imagery. This was called the visual test.

Secondly, the subject was asked to perform a task for which most people

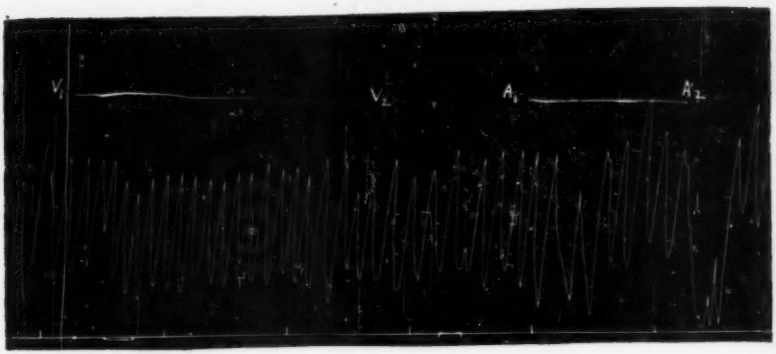


FIG. 3.—This subject shows regular breathing during 'visual test' ($V_1 - V_2$) and irregular breathing during 'auditory test' ($A_1 - A_2$). Time signal 30 seconds.

would use auditory imagery. It had been found from previous questions that most people used predominantly this type of imagery in adding up a column of figures. This test was set, and may be referred to as the 'auditory test.'

In all, 44 normal individuals were examined. Eighteen, or 41·0 per cent., were regular in one test and irregular in the other. Of these 18, all except one exhibited the regular rhythm in the test for which visual imagery was indicated, but irregular rhythm in the test for which auditory imagery was commonly used. The results in one of these cases are shown in fig. 3. In only one doubtful case was the rhythm regular in the adding test and irregular in the visual test. Of the 44, 13, or 29·5 per cent., were regular in both tests and the same number were irregular in both tests. Subjective tests (which will be described later) indicated that 12 of those 13 regular breathers employed predominantly visual imagery, while 10 of those 13 irregular breathers had a preference for auditory imagery.

From the fact, then, that 17 out of 18 individuals showed regular rhythm during the test where visual imagery was indicated, but irregular rhythm where auditory imagery was more suitable, it may be deduced that respiration tends to become regular where an individual is employing visual imagery, and irregular when using auditory imagery.

The fact that 13 individuals breathed regularly both during a test for which visual imagery was indicated and also during a test where visual imagery might or might not be used, suggested that they preferred employing visual imagery to auditory imagery wherever possible. The fact that 13 subjects used irregular rhythm throughout seemed to indicate that they were persons who had difficulty in using visual imagery exclusively at any one time, even where the problem seemed to require the visual type of thinking. As already stated, it was confirmed by subjective tests that 12 of the 13 subjects who breathed regularly throughout both tests employed predominantly visual imagery, while 10 of the 13 whose rhythm was irregular throughout used predominantly auditory imagery.

It has also been stated that tests were carried out on these normals to find out which type of imagery they used. These tests were partly subjective and partly objective.

The subject was first of all asked to think of a clock face with the hands pointing to twenty minutes past eleven. He was then asked to imagine that the big hand was the small hand, and the small hand the big hand, and further asked what the time would then be. The interval which elapsed between putting the question and receiving the answer was noted. The subject was then asked how he did the problem and how easily he could picture the clock face.

He was then shown a sheet of cardboard with the capital letters of the alphabet clearly printed on it. He had to picture each of the letters as he would see it upside down, and told that he would be questioned at the end of the test as to which letters looked the same upside down as the right way up. In fact, H I N O S X and Z look the same upside down as the right way up. If an individual, for instance, included N S and Z he was considered to have a good visual capacity.

Lastly he was asked to look at these dice patterns : ⁘ ⁘ ⁘, and to write them down from memory. The strongest visualists were those who wrote them straight down without saying the numbers to themselves. The strong auditories were those who translated the patterns into the sounds of the numbers and then translated them back again. From these data it was recorded whether the subject used predominantly auditory or predominantly visual imagery. After he had been classed as auditory or visual, the respiratory record was taken and examined to see whether the respiration was regular or irregular in type (Table II). Of the 32 regular breathers, 24, or 75 per cent., were visualists, while of the 33 irregular breathers 24, or 72·8 per cent., were auditories. It would appear then from these figures that regular and

irregular breathing is accompanied in a significant number of cases by visual and auditory imagery respectively.

These findings are in keeping with the work recorded above by previous writers. Peterson and Jung had concluded that regularity was dependent more on intellectual than on emotional factors. The above results would bear out the supposition that where there is no tendency to think in terms of one's own voice the rhythm is peculiarly regular. Where, however, the individual is inclined to vocalize, the rhythm becomes irregular. This irregularity would seem to be dependent on movements of muscles of the chest to a greater extent than of those of the larynx, being noticeable on the record during inspiration, as well as expiration. Those who do not tend to think in terms of their own voice, or use a kind of inner speech, appear from the above results to use predominantly visual imagery.

Further work remains to be done to elucidate the relation of type of rhythm to type of imagery. For instance, the respiration of a series of congenitally blind individuals might be tested in order to ascertain whether they breathe irregularly, and a series of congenitally deaf individuals in order to see whether their respiration is regular. (The latter test would not be so conclusive, since nowadays such patients are taught to vocalize from an early age.)

Respiratory Rhythm during Normal Sleep.—Eight records of three different subjects who fell asleep in a plethysmographic apparatus made on the same principle as that used in the present series were compared with the above records. I am indebted to Dr. Antonovitch for these records, hitherto unpublished. In each case the subject became more irregular in the dozing state which preceded sleep. During sleep the subject became regular. In the case of one who was fairly regular when awake, the rhythm became regular in sleep.

RESPIRATION IN PSYCHOTICS

Records of 179 psychotic patients were examined. Of these, 133 were schizophrenic, 32 were melancholic, and 14 were epileptic. As has been already reported, the schizophrenics differed on the average from normal subjects in that their breathing was shallower and more rapid.

The rhythm of respiration in schizophrenic patients was studied to find out whether it differed in respect of regularity or irregularity from that of normal subjects. The same technique was employed as previously in the case of normal subjects. In all, 136 schizophrenics were examined, 100 males and 36 females. Of these, 94 were classed as regular and 42 as irregular. This represents 69·1 per cent. of regular breathers as compared to 49·2 per cent. of regular breathers in the normal group. Examination of the schizophrenic group showed that the irregular breathers were mostly to be found among those who had been ill for less than five years (Table III and fig. 4). It will be seen from the table that out of those who had been in hospital for

less than one year 11 were regular and 18 irregular. Fig. 4 shows how the percentage of regular breathers goes up according to the length of time that the patient has been in hospital.

TABLE III. RELATION OF REGULAR OR IRREGULAR RHYTHM TO DURATION OF MENTAL DISEASE

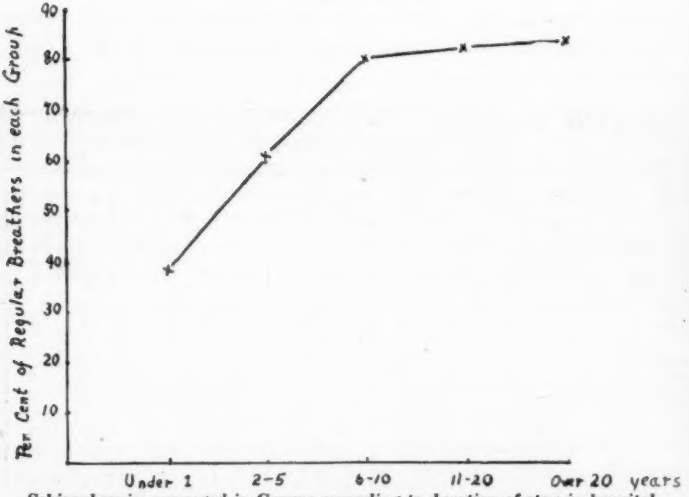
Length of time in hospital	Under 1 year		2–5 years		6–10 years		11–20 years		Over 20 years		Total
SCHIZOPHRENIA	Reg.	Irreg.	Reg.	Irreg.	Reg.	Irreg.	Reg.	Irreg.	Reg.	Irreg.	
Males	7	16	12	6	13	3	22	4	15	2	100
Females	4	2	2	3	3	1	1	1	15	4	36
Total	11	18	14	9	16	4	23	5	30	6	136
MELANCHOLICS											
Males	7	5	0	1	0	0	0	0	0	0	13
Females	7	4	0	5	0	0	0	3	0	0	19
	14	9	0	6	0	0	0	3	0	0	32
EPILEPSY											
Males	0	1	2	1	0	1	0	0	8	1	14

Further analysis of the figures, however, showed that the difference between the percentage of regular breathers among the schizophrenics who had been in hospital less than one year, and those who had been in from two to five years, was not significantly different. Neither of these groups was significantly different from the normal. All the schizophrenic groups, however, who had been in hospital more than five years showed a significantly greater percentage of regular breathers than the other three groups, namely, (1) the normal group; (2) the group of patients admitted less than one year; and (3) the group of patients admitted two to five years previously.

When we examine the records of 32 melancholic patients we find that 14 are regular and 18 irregular. (As only three of these had been in hospital more than five years it was not possible to correlate regularity with the duration of the illness, as has been done in the case of the schizophrenics.)

Of the epileptics who had been in more than 20 years, eight were regular and one irregular. These were all considerably demented. Of those who had been in less than five years, two were regular and two irregular.

It may be observed, then, from these cases that where there is considerable dementia whether in schizophrenics or epileptics, the respiration is usually regular. The most regular were those who were not able to do work of any kind. No marked difference could be seen between the record of the typically regular normal and that of the typically regular schizophrenic. The extremely regular type of rhythm, however, such as is found in sleep, was commoner among schizophrenics than normals. There was no obvious difference between the typically irregular normal and the irregular schizophrenic. Some schizophrenics, however, gave rather unusual respiratory



Schizophrenics arranged in Groups according to duration of stay in hospital.

FIG. 4

In those groups that have been in over six years the number of regular breathers is over 80 per cent. in each case.

FIG. 5.—Periodic breath-holding in a schizophrenic.

records, such as periodic holding of the breath (fig. 5). Another showed a curious tremor of the respiratory muscles during each respiration (fig. 6).

There were still other unusual records which were in keeping with the rhythmical and bizarre character of other schizophrenic symptoms.

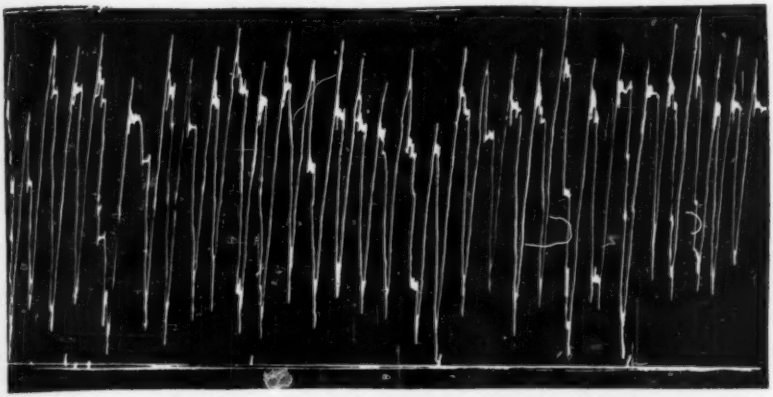


FIG. 6.—Rhythmical tic-like respiratory movements in a schizophrenic.

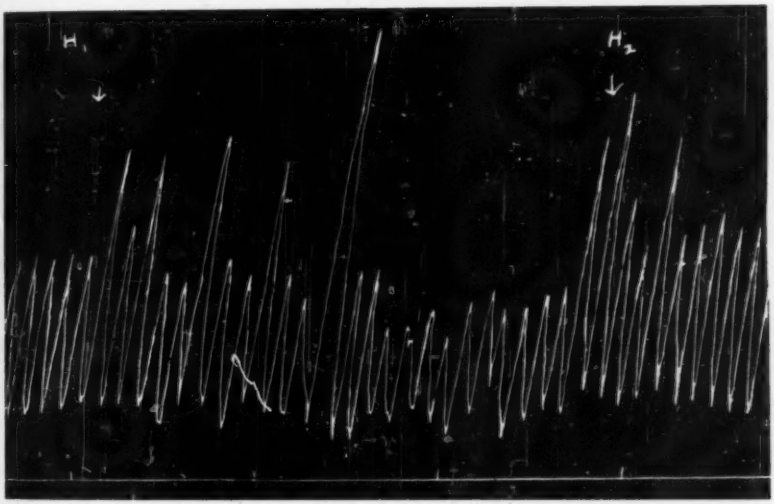


FIG. 7.—Schizophrenic, a regular breather, shows irregular respiration between $H_1 - H_2$, during which time he was hallucinating. No movement of lips or larynx was noticeable.

RECORDS SHOWING HALLUCINATIONS.—It not infrequently occurred in one of these experiments that while a patient was breathing regularly he suddenly started to breathe irregularly (fig. 7). When questioned, he would say

that he had heard a voice speaking to him, even although his lips had not been observed to move. On more than one occasion this occurred where the patient had denied hallucinations, but later admitted them, when asked about his thoughts at the moment when his breathing changed. On other occasions sudden irregularity of breathing was found to be accompanied by olfactory hallucinations.

THE I : E RATIO.—Some writers have claimed to find a difference in the character of the respiratory curve obtained from schizophrenics as compared to that obtained from normals. In these experiments inspiration is represented on a moving drum by an upstroke and expiration by a downstroke. One can compare the duration of inspiration with that of expiration (fig. 8). The duration of inspiration divided by the duration of expiration has been called 'inspiration-expiration ratio.' The expiration period lasts from the

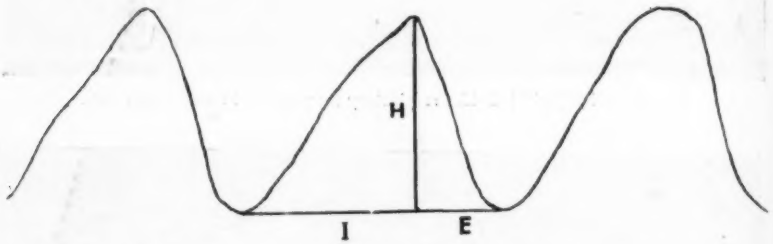


FIG. 8.—The figure is taken from a stethograph tracing, inspiration being represented by an upstroke and expiration by a downstroke. I = duration of inspiration, and E = that of expiration. Some writers have stated that the I/E ratio is different in schizophrenics from normals.

end of inspiration to the beginning of the next inspiration and so includes the respiratory pause. Now if the rate of respiration be decreased the decrease in rate occurs chiefly at the expense of the respiratory pause. Since, then, the respiratory pause is included in the expiratory phase, E will be relatively longer. For instance, Mignot and Le Grand [5] studied a few cases in which there was especially slow respiration. They found that the I : E ratio from being 10 : 14 in normals was as much as 10 : 20 or even 10 : 80. Since, however, in most cases of schizophrenia the rate of respiration is increased, the I : E ratio is less than 10 : 14.

OTHER CHARACTERISTICS OF THE RESPIRATORY CURVE IN SCHIZOPHRENICS.—A great deal of the work done on this subject gave negative results. It has been said by Sandri [9] that in schizophrenics if inspiration is represented by an upstroke, the first half is steeper than the second half. In normals it is said that this feature is much less marked. In expiration also, the first half of the downstroke in schizophrenics is said to be steeper than the second half. In the present series, however, no difference of such a kind

could be seen in the plethysmographic tracings, nor in the thoracic or abdominal tracings where these were also carried out.

REACTIONS TO STIMULI BY NORMALS AND SCHIZOPHRENICS

Both normals and schizophrenics were subjected to certain disturbing factors in order to ascertain whether the latter's change of respiratory depth and frequency was significantly different from that of the former. The first of these consisted of a mental exercise. Not only normals but also those schizophrenics who could give correct answers were asked to add up a column of figures while sitting in the apparatus.

TABLE IV. COMPARISON OF UNDISTURBED RESPIRATION WITH THAT OCCURRING DURING MENTAL TEST (ADDITION) AND DURING PINCH, IN NORMALS AND SCHIZOPHRENICS

	Normals			Schizophrenics		
Addition	h_1 47·5	f_1 17·9	v_1 824	h_1 38·7	f_1 20·3	v_1 786
	h_2 49·6	f_2 22·1	v_2 1037	h_2 43·3	f_2 21·6	v_2 946
Difference	Not sig.	Sig.	Sig.	Not. sig.	Not sig.	Borderline
Pinch	h_1 45·7	f_1 17·4	v_1 762	h_1 35·7	f_1 19·7	v_1 693
	h_2 37·2	f_2 18·3	v_2 654	h_2 29·6	f_2 18·4	v_2 521
Difference	Sig.	Not sig.	Not sig.	Sig.	Not sig.	Not sig.

h_1, h_2 = height of respiratory curve in mm., during undisturbed state and during the respective tests. f_1, f_2 = frequency of respirations per minute. v_1, v_2 = volume, product of h and f. 'Sig.' indicates that the difference between undisturbed and disturbed values is significant. In the 'addition' test there were 43 normals and 34 schizophrenics. In the 'pinch' test there were 20 normals and 20 schizophrenics.

Forty-three normals and 34 schizophrenics were subjected to this test (Table IV). With the normals the height during addition was not found to be significantly different. This, however, may have been due to the fact that too few cases were examined. The frequency and also the total ventilation, however, were significantly greater during addition. In the schizophrenic group the height and frequency were not significantly changed during the mental exercise compared to the undisturbed state. The change of total ventilation was found to be on the border line of significance.

Twenty normals and 20 schizophrenics were also subjected to a painful pinch. Following the pinch there was a significant decrease in the height of the curve both in normals and in schizophrenics. The changes in frequency and volume, however, were not significant in either class.

Statistical analysis showed that the only values of normals in both these tests which could be compared with those of schizophrenics were (1) volume of respiration in the addition test, (2) frequency of respiration during the addition test, and (3) height of respiration during the pinch (Table V).

TABLE V. EFFECT OF STIMULI ON SCHIZOPHRENICS COMPARED TO NORMALS. THE DIFFERENCES WERE RECKONED AS PERCENTAGES OF THE UNDISTURBED VALUE.

		Mean percentage of change	Standard error
Volume of respiration during addition	Volume for normals	+ 29·4	± 6·6
	,, schizophrenics	+ 17·7	± 5·8
Frequency of respiration during addition	Frequency for normals	+ 30·0	± 7·2
	,, schizophrenics	+ 5·3	± 3·2
Height of respiration during pinch	Height for normals	− 19·2	± 4·0
	,, schizophrenics	− 19·0	± 5·9

Only in frequency of respiration is the difference in normals significantly greater than in schizophrenics.

It will be seen from the table that the only significant difference is in the frequency of respiration during addition. This is significantly greater in the normals than in the schizophrenics.

From the above figures, then, no very decisive conclusions can be drawn, owing to the relative amount of scatter, and the relative paucity of material. One can only say that the figures have not proved the existence of a greater or less reaction to pain in schizophrenics. They allow, however, of a tentative conclusion that there is a greater increase of the frequency of respiration during mental exercise in normals than in those schizophrenics capable of correct addition.

Both normal and schizophrenic individuals were also subjected to the sudden hoot of a motor horn and also to the light of a magnesium flare. The reactions, however, varied so much from individual to individual that no conclusion could be drawn.

DISCUSSION

As has been already stated, the whole subject of the relation of normal and pathological mental processes to the respiratory curve is a very large one.

In what follows an attempt is made to answer the three questions which were suggested in describing the scope of the present inquiry.

1. *Is there any particular mental process which gives a special type of respiratory record?*—In the present study there was seen to be a relation between the type of mental imagery, auditory or visual, and type of respiration, irregular or regular respectively. As already mentioned, early investigators obtained no very clear results when they attempted to find characteristic respiratory curves for various emotions. Peterson and Jung, however, stated that the respiratory variations were associated with intellectual rather than emotional changes. Golla and Antonovitch went further and concluded that irregularity was associated with auditory imagery and regular with visual imagery.

In the present study the main argument to prove that regularity of rhythm tends to go with visual imagery was provided by the fact that where the subject was asked to work out a problem requiring visual imagery, the respiration was nearly always very regular except in those cases where the individual appeared from subjective tests to find difficulty in using visual imagery at all. Again, subjects nearly always breathed with an irregular rhythm while doing a test which experience had shown usually to require auditory imagery, with a tendency to vocalization, except where the individual found difficulty in employing any sort of auditory imagery.

An attempt was made to examine 65 normals by subjective and objective tests to see whether they used predominantly visual or auditory imagery. It was then found that regularity of rhythm corresponded to visual imagery in 75·0 per cent. of cases, and irregular rhythm to auditory imagery in 72·8 per cent. of cases. It is possible that these percentages might have been even higher if more elaborate tests had been carried out.

A considerable amount of evidence, therefore, has been brought forward to indicate that regular breathing is accompanied as a rule by visual imagery and irregular by auditory imagery, the subject tending to use a kind of inner speech in the latter case.

2. *Is there any feature which is more frequently, or solely, found in the respiratory curve of a psychotic compared to a normal individual?*—It has been found that the respiration of schizophrenics is more shallow and more rapid on the average than normal subjects. Further, those schizophrenics who had been in hospital more than five years showed a significantly greater percentage of regular breathers than either normals or recently admitted schizophrenics. About 83 per cent. of those who had been in hospital over 20 years were regular compared to 49 per cent. of normals.

Further work is therefore suggested on the subject of the mental imagery of schizophrenics, to find out whether these use predominantly visual imagery, and if so, whether it differs from that employed by most normal persons. The question whether the regularity of rhythm accompanies a mere cessation of mental processes or a series of visual images remains undecided.

Schizophrenic patients were found on occasion to give peculiar kinds of records which would not be found in normal subjects. Some, for instance, showed a regularly recurring phenomenon such as holding the breath. Another feature which was characteristic of schizophrenia was extreme regularity of rhythm broken by a temporary extreme irregularity, followed again by a very regular rhythm. Yet during the irregular period the patient's lips or cheeks were not observed to move. These patients were found to be hallucinating.

3. *Are the respiratory reactions of psychotic subjects to various stimuli different from those of normal subjects?*—It was difficult to devise tests which would give sufficiently uniform results in normals to enable them to be compared to those obtained from schizophrenics. When those schizophrenics

who were capable of giving correct totals in adding up a column of figures were compared to normals, the increase of respiratory rate was significantly less than the increase of rate during adding in normals. No conclusions could be drawn with regard to pain, sound or light reactions.

SUMMARY

1. The respiratory function has been studied in its relation to the higher cerebral centres. A description has been given of previous work on the subject. Some earlier workers had studied the effects of various emotions, pleasant and unpleasant stimuli, etc., on the respiratory rhythm. On the whole the results were disappointing.

2. F. Peterson and C. G. Jung indicated that changes of respiration were more closely related to conscious thought and vocalization than to emotional changes. Golla and Antonovitch found that about 50 per cent. of normal individuals breathed with regular rhythm and about 50 per cent. with irregular rhythm. They stated that the regular breathers more commonly employed visual imagery as an instrument of thought, while the irregular employed predominantly auditory imagery, the tendency to vocalization being responsible for the irregularity.

3. In the present inquiry, an attempt is made to answer three questions in relation to respiratory rhythm. (*a*) Is there any particular mental process which in normal subjects gives rise to a special type of respiratory tracing? (*b*) Is there any feature which is more frequently found, or any feature which is only found, in the respiratory record of a psychotic individual as compared to a normal? (*c*) Are the respiratory reactions of psychotic subjects to various stimuli different from those of normal subjects?

4. The respiratory records of 65 normal subjects, and of 178 psychotics were examined. Of the normals, 32 breathed with a regular rhythm and 33 with an irregular rhythm. The various causes of irregularity of respiratory rhythm are investigated, and evidence is brought forward to show that auditory imagery with its tendency to vocalization is responsible for this irregularity, when other causes have been excluded.

5. The following facts support this conclusion. Forty-four normal individuals were first set a problem, the solution of which would ordinarily demand visual imagery, and then one which would require auditory imagery. Eighteen were regular in one task but irregular in the other. Of these 18, all except one showed regular rhythm in the test for which visual imagery was indicated but irregular rhythm in the test for which auditory imagery was commonly used. Thirteen individuals were regular in both tests, and 13 irregular in both tests. Subjective examination of these individuals indicated that 12 of the 13 regular breathers employed predominantly visual imagery, while 10 of the 13 irregular breathers had a preference for auditory imagery.

6. Of the 136 schizophrenics, 94 were regular and 42 irregular. When

these were arranged in groups according to the length of time spent in hospital, of those who had been in hospital less than one year 38 per cent. were regular; of those from two to five years, 61 per cent. were regular; from six to ten years, 80 per cent.; 11 to 20 years, 82 per cent., and over 20 years, 83 per cent. Thus among the groups who had been in hospital more than five years, the proportion of regular breathers was significantly higher. Of the 32 melancholic patients, only three of whom had been in hospital more than five years, 14 were regular and 18 irregular.

Of the epileptics who had been in hospital more than 20 years, eight were regular and one irregular. These were all considerably demented. Of those who had been in less than five years, two were regular and two irregular.

7. There was no characteristic difference between the regular rhythm of normal subjects and that of schizophrenics. In the latter group, however, an extreme degree of regularity was more frequent. They also showed on the whole a shallower and more rapid rhythm. Some showed records of a peculiar character not found in normals. Those with hallucinations showed characteristic records, the extreme regularity being broken by extreme irregularity during the hallucinations, even when there was no movement of lips.

8. Reactions of the respiratory mechanism to stimuli were studied in normals and schizophrenics. Not enough cases were examined to give definite results owing to the scatter among normal subjects. There was a significant difference, however, between the reaction of those schizophrenics who were able to perform an intellectual exercise, and normals. The schizophrenics did not react with so great an increase of respiratory rate.

My thanks are due to Dr. F. L. Golla, Director of Research, London County Mental Hospital Service, at whose suggestion this work was carried out, for his unfailing interest and help, and to Drs. E. Mapother and J. Brander for giving me access to the patients of the Maudsley and Colney Hatch Mental Hospitals.

This work was done while holding a Commonwealth Fellowship at the Maudsley Hospital, London. The collation and elaboration of results were worked out during the tenure of a Pinsent-Darwin Research Studentship from Cambridge University. It comprised part of a thesis for the degree of Doctor of Medicine of Edinburgh University.

REFERENCES

[1] Angell, J. R., and Thomson, H. B., *Psychol. Rev.*, 1899, 33.
[2] Golla, F. L., and Antonovitch, S., *Brain*, 1929, **52**, 491.
[3] Lehmann, Wundt's *Phil. Stud.*, **9**, 66.
[4] Mentz, P., *ibid.*, **11**, 61.
[5] Mignot and Le Grand, *Presse Méd.*, 1926, **34**, 1474.
[6] Paterson, A. S., *Jour. Neurol. and Psychopathol.*, 1934, **14**, 323.
[7] Peterson, F., and Jung, C. G., *Brain*, 1907, **30**, 153.
[8] Rehwoldt, F., Wundt's *Psych. Stud.*, **7**, 141.
[9] Sandri, P., *Note Psich.*, 1928, **16**, 401.
[10] Zoneff and Neumann, Wundt's *Phil. Stud.*, **18**, 401.

SOME OF THE STRUCTURAL ABNORMALITIES PRESENTED BY THE BRAINS OF THIRTY-ONE CERTIFIED MENTAL DEFECTIVES

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INTRODUCTION

In this paper an attempt is made to analyse, by rather different methods than the more purely anatomical, certain macroscopic features of the brains of 31 certified mentally defective patients, details of which are given in Appendix I.

Studies of the macroscopic appearances of the defective brain, in so far as these are causally associated with the resultant mental deficiency, have not been, in the past, very numerous. Fernald, in the *Waverley Researches in the Pathology of the Feeble-minded*, speaks of the 'extraordinary neglect into which this topic has fallen,' and adds that 'the anatomy of feeble-mindedness has not been attacked systematically over a period of years.' Fernald himself endeavoured to bridge this gap by giving complete anatomical descriptions of the brains of 10 defectives. But purely descriptive anatomical methods no longer suffice and are of little or no help to the mental specialist. Even the descriptions given in the most modern text-books of anatomy are of so stereotyped a nature as to afford no measurable standard against which to set supposedly less well developed brains. As the anatomical description of the normal human brain no longer accords with more recently discovered facts of cortical construction it is obviously in need of revision.

Craniologists, on the other hand, have long abandoned purely descriptive methods as applied to human skulls and have substituted therefor a series of accurately recorded drawings from which measurements and angles can be subsequently calculated. From these can be established almost any desired comparison between normal and abnormal.

It is on these lines that it is now proposed to discuss some of the macroscopic details of these 31 defective brains, and for these purposes the dioptrograph, as an instrument of precision, is as well adapted for the brain as the skull, though it is obvious that for both skull and brain dioptrograph tracings have their limitations.

In a previous communication to this Journal the brains of two of the present series (nos. 8 and 9) were macroscopically and microscopically described and illustrated.

The fissuring of the cortex of the whole of the present series is as obviously irregular as was that of these two and is so in very much the same places—

namely, the pre- and post-central cortical areas, the effector precentral gyrus, the opercular cortical areas and the parietal association areas. In fact, the anatomical descriptions previously given of brains 8 and 9 would apply, with but little modification, to most brains in the series. From a naked-eye examination alone of the sulci and gyri and their marked irregularities it would be legitimate to draw the conclusion that these brains are not, and never have been, sufficiently developed to give normal human reactions to normal human environments.

But such general and personal impressions require some more substantial support than the unaided eye of the observer. Hence dioptrographic tracings of the right cerebral hemispheres of the whole of the series were made. On these, lines and angles could be measured, planimeter areas recorded, and the main features of the fissuring studied and measured as future experience might suggest. Whilst this method permits of an accurate comparison between any two or more brains of the series it does not, with very few exceptions, permit of that comparison between abnormal and normal which it is so essential to establish, because the corresponding data for the normal are not yet known.

PERSONAL STUDIES

Commencing first with those facts which do permit of an accurate comparison between these 31 defective brains and those usually accepted as representative of the normal there fall to be considered :

1. The angle of the Rolandic fissure.
2. The length of the Rolandic fissure.
3. The height and index of the skull and brain.
4. The actual size of the cortical hemisphere itself.

1. ' The acute angle which the slope of the fissure of Rolando (central sulcus) forms with the superior border of the hemisphere is known as the *Rolandic angle*. According to Cunningham it averages 71·7° ' (Quain). Eberstaller found that in adults it varied from 70° to 75°. In these defectives the Rolandic angle only averaged 56·5° with a variation of from 31° to 90°, the latter occurring in Case No. 19, which was complicated by ventricular hydrocephalus. In view of the experience of Ariëns Kappers, who found that the Rolandic angle acquires its definite position only about the fifth month after birth, this range of variability in defectives is suggestive of a fœtally ill-developed brain retained throughout life.

2. *The length of the Rolandic fissure* measured between the two extremities of the fissure and in a straight line over the arc of the hemisphere is given by Quain as about 3¾ inches (8 cm.) and by Symington and Crimble as about 9 cm. in direct line from the ends of the fissure, and 10·4 cm. following the curves of the sulcus.

On the dioptrographic tracings of these defective brains it is the chord, not the arc, which is measured, and this averages only 5·7 cm. with extremes from 4·3 cm. to 8 cm., from which it would appear that these defective brains

show significant reduction in the length of the Rolandic fissure. As this fissure is a cortical infolding between the whole lengths of the important postcentral somæsthetic area and the precentral effector, it follows that a significant reduction in the length of the Rolandic fissure denotes, in these defectives, a diminution in the functional cortical tissue of the greatest importance in mental activities.

3. The *height index* is a ratio between height of skull and length, and is used by craniologists as a standard of racial comparisons. Combined with other measurements and indices it gives some indication of the form of the head and associated size of the brain. The index is expressed by the formula

$$\frac{\text{Basal height} \times 100}{\text{Maximum length}}$$

In general, the lower the index the lower the cranial form, and the index usually ranges from 72 to 77. Skulls with the former reading or less are technically termed platy- or tapeinocephalic. In children's crania the average index is 75·2 (Duckworth).

Dioptrographic tracings of one cerebral hemisphere enable the similar index for the brain to be calculated with the greatest accuracy. In the present series of defective brains the cerebral height index only averages 60·3, with extremes from 54·4 to 72·7—that is, all have lower cerebral indices than the corresponding average cranial figures given by Duckworth for children.

4. *The actual size of the cerebral hemisphere itself.* Notwithstanding the large amount of information for brain weights, cubic content of skull, and similar facts, there is but little available for actual linear dimensions of the normally developed cerebral hemispheres, and without this it is very difficult to institute comparisons of size between defective and normal brains. Several leading English and American text-books of anatomy or neurology seem, however, to make the following fairly uniform statement :

'The length of the cerebral hemisphere measured from the frontal to the occipital pole varies in the majority of cases from 160 mm. to 170 mm. for the male, and 150 mm. to 160 mm. for the female. The *greatest* vertical diameter is 125 mm.' (Tilney and Riley). It will be observed that these, at best, but scanty facts afford a range of variation for cerebral length but give only the *greatest* vertical diameter. The corresponding facts for these 31 defective brains and their comparison with the figure just given in the reputedly normal brain may be tabulated as follows :

Normal	Defective
Fronto-occipital length : Males, 160 mm. to 170 mm.	160 mm. (14 males)
Fronto-occipital length : Females, 150 mm. to 160 mm.	152 mm. (17 females)
Greatest vertical height : Both sexes, 125 mm.	100 mm. (31 cases)

As regards cerebral length the defectives stand at the lowest known figure quoted for normality. For vertical height they are 25 per cent. less than the ' greatest ' vertical height. This last fact, read in conjunction with standard anthropometric methods of calculating cubic contents of skull from measurements of length, breadth and height, assumes clinical significance because it substantiates other observations on the occurrence of small-headedness (microcephaly) in about two-thirds of certified defectives. In the brains of these 31 defectives the dioptrographic measurements of vertical height ranged from 80 mm. to 120 mm. (once) with the average already given.

Male occipitofrontal length ranged from 145 mm. to 180 mm. (once) and the last was pathological. Female cerebral length ranged from 138 mm. to 170 mm.

With the objective of establishing, if possible, some direct comparison of cerebral size between defectives and normals it was determined to multiply

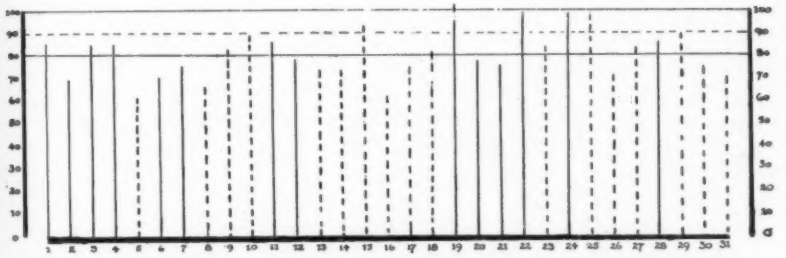


FIG. 1.—Diagram showing the sizes of the 31 defective brains in percentages of the lowest available normal figure, the latter being taken as 100 per cent. Males are shown by continuous vertical lines, females by interrupted ones. The numbers at the bottom are those of the cases as set forth in Appendix I, whilst the percentages are on either side.

cerebral length and breadth together, taking the lowest available figures for normality and regarding the product as 100 per cent., to convert the slightly lower figures for normal females to the same standard by means of the factor 1·067 and then to set against this scale the actual figures for the defectives. The results of this procedure are shown in fig. 1, where the defectives are arranged in chronological order of age—that is, in the same order as that given in Appendix I.

The first and most striking fact brought out by this comparison of cerebral length-height area of size is that the defectives have a brain 20 per cent. less than the lowest figure for normals.

Secondly there is, in these defectives, little if any indication of an association between advancing age and size of brain. It is true that the individual differences are so great that any such association might be obscured, but in addition it is not unlikely that the defective brain does not undergo those increments in size with age that it should.

DISCUSSION OF RESULTS

In so far, therefore, as it is possible to establish comparisons of these defective brains with known data for normals for size of brain, length and angle of the Rolandic fissure, length of the associated cortical areas, and the cerebral height index, all the observations—taken either separately or collectively—go to suggest that the defective brain more nearly resembles that of an eight-months' fœtus than of a more normally postnatally developed one. For subsequent post-natal, and, in these cases, slight differences of mental reactions, it seems most likely that microscopic investigation can alone indicate what, if any, are the post-natal cerebral alterations in the brains of defectives as contrasted with normals. Whatever their nature, that they are of an abnormal character seems certain, as does also the fact that, minute though they may be in nature and origin, they are mirrored in the macroscopic appearance of the brain itself.

Passing next to the consideration of the variability of these defective brains within themselves and for which there are insufficient or no data available for comparison with the normal, there may first be discussed the variability in the actual sizes of the defective brains themselves.

It has already been pointed out that in these series of 31, the average defective brain is 20 per cent. less than the lowest normal. Fig. 1 shows that even this low figure is not uniform but displays a considerable range of variation from 61 per cent. of the normal (Case 5) to 103 per cent. in Case 19.

Six cases are only 70 per cent. or less of the normal. Nine cases are between 70 and 80 per cent. of the normal. Eleven cases are between 80 and 90 per cent. of the normal. Four cases are between 90 and 100 per cent. of the normal. One case is above the lowest normal with 103 per cent.

As regards those defectives whose brain size was 90 per cent. or less than that of the lowest normal there does not appear to be any significant or ascertainable association between these variabilities in brain size and the mental ratios during life. Thus Case 31, with a brain size only 70 per cent. that of the normal and a chronological age of 35.11 years, had a Binet mental ratio of 6.10 years, whereas none of the nine cases between 70 and 80 per cent. of the normal, and with ages ranging from 4.8 years to 30.7, had an ascertainable mental age during life of more than three years.

When, however, attention is directed to the five cases with 90 per cent. and upwards of the lowest normal brain size—i.e. to those more nearly approaching normality—some possibly significant facts begin to emerge.

Of these five cases, which are those with the largest brains in the series, one—15—is the highest grade case of all, having been rated during life as low grade feeble-minded with a Binet mental ratio of 6.10 years. Two—Cases 19 and 22—are definitely pathological (ventricular hydrocephalus and tuberous sclerosis), whilst the remaining two (24 and 25) certainly seemed, on microscopic examination, to owe their comparative but relative

bigness of brain to other pathological conditions not obvious to the naked eye but revealed by the microscope, one case being definitely due to an abnormal glial increment.

It would thus seem as though defectives are so on account of their ill-developed and unduly small brain : in this respect they are, even within themselves, extremely variable, and lastly, that those more nearly approximating to normality in brain size only do so on account of a more nearly normal mental ratio or of some underlying pathological condition of a gross or microscopic nature.

FURTHER PERSONAL STUDIES

In view of this large and apparently not insignificant range of variation in the brain size of defectives an attempt was next made to discover, if possible, wherein these differences lay. Was some part relatively over-developed in relation to others ? Were there, for instance, any appreciable or discoverable differences between prerolandic cortex and postrolandic—that is, between frontal lobe and the rest ? To attempt to answer these questions proved by far the most difficult part of the investigation, and notwithstanding the many and varied procedures adopted all seemed to result in consistent failure to produce any result at all—let alone an understandable one.

'The general conclusion (says Herrick) to be drawn from the entire series of physiological and pathological studies of the cortex is that specific mental entities are not resident in particular cortical areas, but that cortical functions involve the discharge of nervous energy from one or more sensory centres to various and remote regions . . . the destruction of any part of the cortex or of the fibre tracts connected therewith involves first a permanent loss of the particular functions served by the neurones affected, and in the second place a transitory disturbance of the cortical equilibrium as a whole (diaschisis effect).'

Speaking very generally and in terms of the foregoing quotation, it may be accepted that the postrolandic portions of cerebral cortex (the anatomical parietal and occipitotemporal lobes) are more definitely receptor or sensory in function than is the prerolandic frontal lobe. Further, if under normal conditions of cerebral development subsequent destruction of any part of the cortex produces those recognizable effects mentioned by Herrick, then the question arises : does a maldevelopment, or a grossly unequal distribution, of postrolandic and prerolandic cortex produce similar effects and, if so, in what way are the behavioural reactions of the individual altered from those resulting from more normally developed brains ?

As already mentioned, many attempts were made to provide, from the present series of defective brains, some negative or positive answer to these problems, with but little appreciable result. After much discussion with the Medical and Consultant Staffs it was eventually decided to compare the actual

planimeter areas of the pre- and postrolandic cortical regions. There was accurately recorded on the dioptrographic tracings of the lateral (external) surface of each of these defective brains the superior and inferior Rolandic points, the central sulcus of Rolando, the lateral Sylvian fissure, the precise point at which the parieto-occipital fissure cut the superomedial border of the cerebral hemisphere, as well as the main cerebral sulci themselves. With these points and lines accurately located it was easily possible to draw in on the dioptrographic tracing the line of the chord of the Rolandic fissure, the chord of the parietal arc, and the outlines of the external surface of the parietal lobe itself. The anatomical description of the delimitation of this surface of the parietal is so inaccurate and misleading as to be useless for purposes of measurements. In the present series the parietal lobe is delimited by the Rolandic fissure; the superomedial border of the hemisphere from the superior Rolandic point to the parieto-occipital fissure, and completed by a line drawn from that point to the inferior Rolandic point or a line drawn vertically therefrom to the Sylvian fissure. The importance of the enclosed portion of cortex lies in the fact that within it is the parietal association area so closely related, structurally, to the incoming neural streams from the primary visual, acoustic and general somæsthetic senses. These facts are in themselves so important as to necessitate some more accurate method of parietal lobe delimitation than that given in textbooks, hence the method herein suggested and adopted.

The pre- and postcortical areas having thus been accurately delimited on the dioptrographic tracings, as well as the component parts of the post-rolandic cortex—that is, its parietal and occipitotemporal constituents—the extent of each area was easily obtained by the planimeter, with the results given in Appendix II.

It is to be noted that this method is open to criticism, inasmuch as it only measures cortex visible on the surface and takes no account of that within the depths of the sulci, usually estimated at twice the amount on the surface. Secondly, it does not deal with the total amount of anatomical lobar cortex, but only with that present on the lateral or external surface of the brain; and, lastly, it records only the linear extent of the areas measured, taking no account of the convex surface involved.

But other methods, such as Wagner's, of covering the whole of the cortex with gold leaf and determining the extent of surface by the amount employed, or Baillarger's attempt at dissecting off the grey cortex from the white matter, are so laborious as to be impracticable over any large series of observations, and if these are not sufficiently numerous the results are of little practical value. It is therefore impossible, at the moment, to establish any comparison of the inequality of cortical areas as between normal and abnormal. The latter, however, proved even with the dioptrographic method to present so many variations as to justify the time and labour bestowed on their ascertainment.

Fig. 2 displays these 31 defective brains in order of the actual extent of their prerolandic frontal cortex (solid black columns). To the immediate left is shown for each case the total amount of postrolandic cortex, the parietal portion of which is indicated by vertical lines, whilst the occipitotemporal is

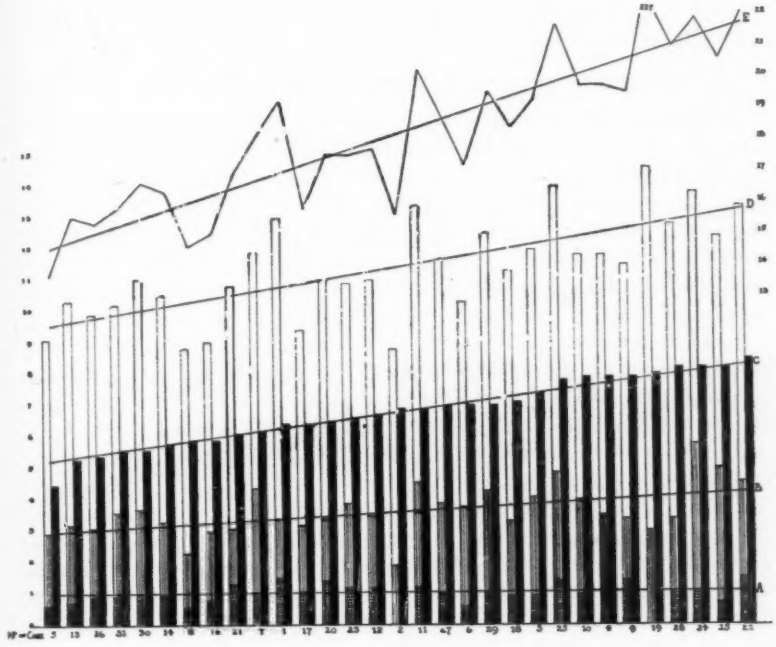


FIG. 2.—Diagram showing the areas of the pre- and postrolandic cortices on the external surfaces of the brains of 31 defectives, arranged in order of size of area of the prerolandic cortex.

The prerolandic cortex is indicated by the solid black vertical column, with the postrolandic portion to their immediate left. The parietal part of the latter is vertically shaded, and the occipitotemporal unshaded.

The cuneus on the medial surface of the brain is, for diagrammatic purposes, indicated by the cross-hatched lower area.

The line A indicates the average slope of the cuneus area; the line B that of the parietal; the line C the prerolandic cortex; the line D that of the postrolandic cortex; whilst the line E indicates the average slope of the actual sizes of the brains themselves.

For the interpretation of the diagram see text.

left clear. The small cross-hatched area at the bottom of the left-hand column has nothing to do with the amount of cortex measured on the external cerebral hemisphere and will be separately referred to later. As between two of the extremes of the series, Cases 5 and 15, the diagram shows, for example, that the amounts of the pre- and postrolandic cortices were as follows :

	Case No. 5	Case No. 15
Prerolandic	4·54 sq. in.	8·25 sq. in.
Postrolandic	9·13 ,,	12·37 ,,
(*a*) Parietal	2·93 ,,	5·04 ,,
(*b*) Occipitotemporal	6·20 ,,	7·33 ,,
Total brain surface	13·67 ,,	20·62 ,,

Whatever the mentality, and whether normal or abnormal, it seems difficult to believe that one individual can have almost twice as much effector or prerolandic cortex as another without affecting, in some way, his behavioural reactions to the environment. In the two cases contrasted above, one—Case 5—is that of an imbecile with an assessed mentality during life of less than three years, whereas the other—Case 15—has the highest mental ratio of the series, with a Binet mental age of 6.10 years and a chronological age of 17.7 years.

But the brain of Case 15 is not only one of the best endowed with a prerolandic cortex (Case 22 is excluded because it was definitely pathological) but is also the most evenly proportioned as regards its ratios of parietal and occipitotemporal receptor constituents to prerolandic effector; this was also the case which most nearly approached during life to the lower levels of normal mentality.

The diagonal line D represents the average amounts of postrolandic receptor cortex, whilst the line B represents only that portion of it which is formed by the parietal area. If the parietal cortex—which is very important for the reasons already given—kept pace developmentally with the rest of the postrolandic cortex, the two lines B and D would be more nearly parallel. That they are not so shows that in these defectives the parietal association area is, relative to the rest of the brain, lagging behind in development. This observation is further supported by the fact that the diagonal line C, which represents the average of the prerolandic effector cortex, is so much more nearly parallel with the line D, which is the average for the whole of the postrolandic receptor cortex.

Differently expressed, the proportion of postrolandic receptor cortex to prerolandic is more uniform throughout than is that of the parietal association area. As the latter forms a part of the postrolandic cortex it again suggests that it must be chiefly this part of the brain which is at fault in the defective.

Assuming that it really is the parietal association area which lags behind in development, what meaning—if any—is to be attached to the fact clinically?

It is stated that stereognosis and barognosis—the abilities respectively of recognizing objects by palpation, or of assessing different weights—both belong to a special form of body feeling (Tilney and Riley) and that the

cortical area specially concerned is usually described as occupying the upper portion of the intermediate postcentral area which is bounded below by the horizontal limb of the interparietal sulcus, and in front by the dorsal division of the ascending limb of this fissure. In other words, these two abilities are chiefly mediated by parietal cortex.

In the well-known Binet tests there are two—one for the fifth year and one for the ninth—designed to assess the stereognostic, or, more accurately, the barognostic, sense. That for the fifth year is useless for any purpose, as only two weights are employed, and thus whatever the defective does the chances are always even that he scores a success. That for the ninth year is free from such objection, but unfortunately many defectives never get so far as the nine-year tests. As this perception is, however, supposed to be mediated by parietal cortex, and as this present study suggests that it is precisely this area which is most undeveloped in defectives, it was clearly desirable to ascertain how far, if at all, clinical observations on abarognosis compared with the ill-developed parietal association area as measured after death and suggested by the pronounced microcephaly revealed by head measurement during life.

With this object the Binet records of 113 living defectives of sufficiently high grade to have attempted the nine-year-old weight test were examined, the assumption being that the clinical microcephaly might possibly be indicative of an imperfectly developed parietal lobe, in which case there should theoretically be an associated higher percentage of barognostic failures. The results were as follows :

Percentile of head size	Nos. of cases	Failed at test	Passes
Below zero percentile	23	20	3
0 to 10	38	26	12
10 ,, 20	16	9	7
20 ,, 30	10	7	3
30 ,, 40	2	2	0
40 ,, 50	6	6	0
50 ,, 60	6	2	4
60 ,, 70	2	1	1
70 ,, 80	3	0	3
80 ,, 90	2	2	0
90 ,, 100	3	3	0
Above 100	2	2	0
	113	80	33

These results are shown in fig. 3, in which the percentages of those that fail and those that pass the test are plotted for each level of head size. There is a notably greater proportion of failures amongst the very small heads ;

for heads of more normal size the proportion of successes is somewhat greater, while among the abnormal macrocephalics the proportion of failures again rises.

Apart from any problem of cerebral localization, there would thus seem to be clinical support for the conclusion previously drawn that defectives have feebly developed parietal areas.

Two other problems presented by the investigation—namely, size of cuneus and ratio of corpus callosum to brain—may next be briefly discussed.

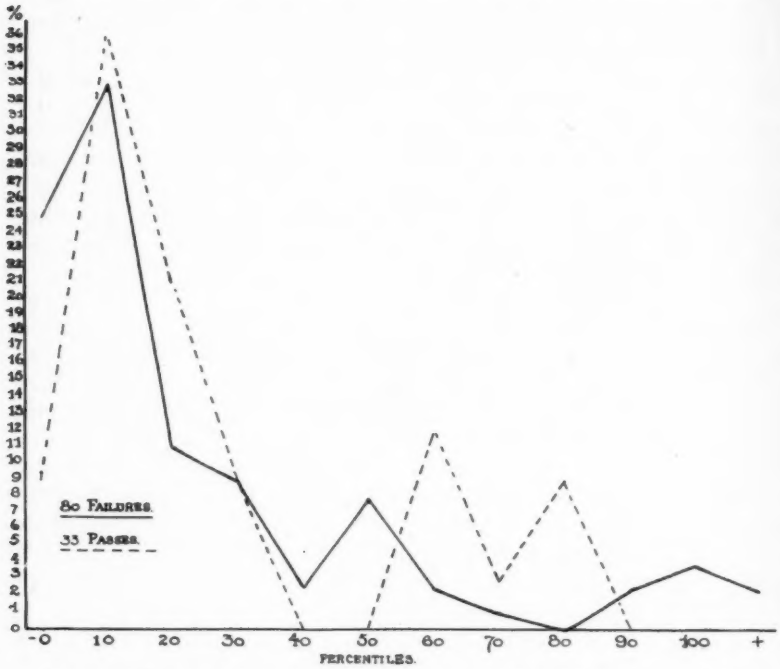


FIG. 3.—Diagram showing the percentages of cases that failed or passed the nine-year old Binet barognostic test and the association of failure or success with the percentile size of skull and brain.

The 80 failures are indicated by the continuous line, and the 33 passes by the interrupted line. The figures on the left are percentages, those at the bottom, percentiles.

The Cuneus.—As the cuneus contains within its area parts of the visuosensory and visuopsychic cortices it was thought that readings of its planimeter area might show some association—negative or positive—with other parts of the brain, or might even link up with mental differences between these defectives during life. The actual planimeter areas of the cuneus are shown for these cases in fig. 3 by cross-hatched portions drawn at the bottom of the columns for postrolandic cortex.

The cuneus, lying as it does on the medial or internal surface of the brain, has nothing to do, macroscopically, with the postrolandic cortex on the external surface, and is merely shown graphically in this way in order to avoid a multiplication of unnecessary diagrams. But even thus one point emerges. The line A shows the average area of the cuneus in the 29 cases in which it was possible to obtain it (Cases 2 and 19 being unobtainable). It will be observed that cuneus development (line A) does not keep pace with parietal (line B). A permissible neurological inference is, therefore, that as the parietal association area is not being properly fed by visual stimuli, increments therein are more due to somæsthetic or acoustic stimuli.

Assuming the correctness of these inferences—though there may possibly be other explanations not so obvious—they would seem to suggest that defectives, as a class, are more dependent on general somæsthetic impulses from within their own bodies than they are on exteroceptive stimuli from without. They further suggest that these disabilities are structurally present before birth, and if, therefore, these important sensory or receptor stimuli are so lacking, all that can be done after birth is to make the most, therapeutically, of the little the defectives have got.

The Corpus Callosum.—The corpus callosum is composed of the medullated axons of commissural neurones with their cell-bodies in the grey cerebral cortex. As the corpus callosum is the only commissure developed in connexion with the neopallial cerebral hemispheres it follows that, theoretically, there should be some association of size of corpus callosum with neopallial cellular richness. As defectives are presumably deficient in some way or other in such wealth of properly functioning cortical cells, measurable variations in size of their corpora callosa might reasonably be expected. This investigation shows that they do, but it failed to demonstrate any appreciable correlation between size of corpus callosum and size of brain. This negative result is not, however, surprising, for size of brain in defectives varies with many factors other than cortical richness of functioning neurones, and it is this last fact alone which is, or should be, chiefly responsible for callosal structure and size.

CONCLUSIONS

From this series of 31 defective brains two facts definitely emerge: One, that the defective brain is 20 per cent. less than that of the lowest normal, and that even within this low standard the range of variation is considerable; two, that there is a measurable disproportion between the main pre- and postrolandic cortical constituents, and that this disproportion is particularly noticeable in the parietal region.

Fig. 2 shows this inequality of the pre- and postrolandic areas, and particularly the fact that it is the parietal lobe which most lags behind in a development proportionate to the rest. In view of the anatomical position of that lobe relative to the cuneus, superior temporal lobe and postcentral

gyrus—that is, to the cortical areas where are first received visual, acoustic and somæsthetic impulses—it seems impossible to doubt that when the parietal lobe is underdeveloped, as in these defectives, the 'reception, association and co-ordination of impressions derived from the organs of special sense' must be so impaired as to result in serious mental deficiency. There is, therefore, an adequate neurological explanation of the mental status of the present series of cases.

Bolton's insistence, in his *Henderson Trust Lectures* of 1933, on the importance of an adequately developed and well-proportioned prerolandic effector area (frontal lobe) in all normal mental activities fully bears out the present investigation and particularly the facts elicited in fig. 2, where the remarkable irregularities between the frontal effector area and the rest of the brain are readily seen.

In persons with brains so irregularly developed and so lacking in the proper proportions of receptor and effector cortices—that is, in defectives—there must necessarily be a diminished sensibility to, and perception of, the external world around them. They thus have to rely far too much on purely bodily stimuli from within, with results which profoundly alter their mentality and may even make them react to their human environment in an abnormal or asocial manner, and this defectives—especially the lower grade ones—most certainly do.

To my colleagues Drs. R. G. Gordon, R. M. Norman and J. A. Fraser Roberts, my thanks are due for their many valuable criticisms and suggestions.

APPENDIX I

Details of the Cases forming the Subjects of the Investigation arranged in order of Chronological Age

No. 1. Male, aged 4.8 years. Idiot. Unable to do the simplest test. Wet and dirty (0 marks). Unable to walk (0 marks). Speechless (0 marks). No educational attainments (0 marks). Brain capacity percentile at approximately the two-year-old level.

No. 2. Male, aged 8.0 years. Idiot. Impossible to test. Wet and dirty (0 marks). Unable to walk (0 marks). Speechless (0 marks). No educational attainments (0 marks). Brain capacity percentile not known. Complicated by a vascular pseudoporencephaly.

No. 3. Male, aged 8.3 years. Idiot. Physiological marks 0. Umbilical hernia. Rickets. Enuresis. Extreme hypotonia.

No. 4. Male, aged 8.11 years. Idiot. Physiological marks 0.

No. 5. Female, aged 9.7 years. Mongolian imbecile. Assessed mental age during life less than three years. Clean habits. Walked well. Limited speech. No educational attainments. Physiological marks 40. Brain capacity percentile −45.

No. 6. Male, aged 11.10 years. Imbecile. Brain capacity percentile 4. Binet mental age 4.2 years, Porteus 4 years. Combined I.Q. 37. Physiological marks 40.

No. 7. Male, aged 12.3 years. Mongolian idiot. Brain capacity percentile −9. Mental age less than two years. Wet and dirty. Speechless. No educational attainments. Physiological marks 15.

No. 8. Female, aged 12.3 years. Imbecile. Brain capacity percentile −19. Merrill-Palmer mental age 6.1 years. Physiological marks 40.

No. 9. Female, aged 12.1 years. Idiot. Physiological marks 15. Paralysed and crippled.

No. 10. Female, aged 13.3 years. Imbecile. Brain capacity percentile 5. Merrill-Palmer mental age 3.8 years. Physiological marks 30. Irritable, epileptic, and with phenomena resembling cerebral diplegia.

No. 11. Male, aged 14.0 years. Idiot. Brain capacity percentile 15. Physiological marks 15.

No. 12. Male, aged 15.4 years. Mongolian imbecile. Merrill-Palmer mental age 5.10 years. Physiological marks 25.

No. 13. Female, aged 15.8 years. Idiot. Wet and dirty. Unable to walk. Speechless. No educational attainments. Physiological marks 0.

No. 14. Female, aged 16.10 years. Mongolian idiot. Brain capacity percentile −8. Physiological marks 20.

No. 15. Female, aged 17.7 years. Low grade feeble-minded. Brain capacity percentile 16. Binet mental age 6.10 years, Porteus 11.6 years, and combined I.Q. 57.5. Clean habits. Limited powers of walking. Some educational attainments. Physiological marks 90.

No. 16. Female, aged 17.9 years. Idiot. Brain capacity percentile −7. Physiological marks 20. Paralysis.

No. 17. Female, aged 18.3 years. Imbecile. Brain capacity percentile 19. Merrill-Palmer mental age 2.8 years. Physiological marks 30. Blind, and suffered from fits.

No. 18. Female, aged 19.0 years. Idiot. Brain capacity percentile −1. Merrill-Palmer mental age 2.9 years. Physiological marks 15. Blind and very restless.

No. 19. Male, aged 20.6 years. Imbecile. Physiological marks 40. A pathological case of ventricular hydrocephalus.

No. 20. Male, aged 21.0 years. Imbecile. Physiological marks 40. Brain capacity percentile 4.

No. 21. Male, aged 21.2 years. Idiot. Physiological marks 10.

No. 22. Male, aged 21.5 years. Idiot. Brain capacity percentile 43. Physiological marks 10. A pathological case of tuberous sclerosis.

No. 23. Female, aged 22.6 years. Brain capacity percentile 7. Physiological marks 70.

No. 24. Male, aged 23.8 years. Idiot. Merrill-Palmer mental age 1.8 years. Physiological marks 5. Dull and vacant expression, with blindness of left eye.

No. 25. Female, aged 24.0 years. Imbecile. Brain capacity percentile 11. Merrill-Palmer mental age 6.6 years. Speechless. No educational attainments. Physiological marks 25.

No. 26. Female, aged 24.5 years. Imbecile. Merrill-Palmer mental age 6.6 years. Physiological marks 40.

No. 27. Female, aged 24.9 years. Feeble-minded. Physiological marks 85. Encephalitis lethargica.

No. 28. Male, aged 27.3 years. Idiot. Excitable. Physiological marks 25.

No. 29. Female, aged 30.7 years. Imbecile, high grade. Physiological marks 60.

No. 30. Female, aged 30.10 years. Imbecile. Brain capacity percentile −13. Merrill-Palmer mental age 4.0 years. Physiological marks 30.

No. 31. Female, aged 35.11 years. Imbecile. Merrill-Palmer mental age 6.6 years, Binet 6.10 years, Porteus 5 years, and combined I.Q. 37.

Cases 2, 19 and 22 were associated with definite and easily recognizable pathological conditions. These respectively were pseudoporencephaly of vascular origin, ventricular hydrocephalus, and tuberous sclerosis.

The physiological system of markings referred to was devised by the author for the early assessment of oligophrenia and is on the following arbitrary scale :

	Minimum	Intermediate	Maximum
Habits			
Wet and dirty	0		
Clean			10
Walking			
None	0		
Limited or impaired		5	
Good			15
Speech			
None	0		
Limited		15	
Good			30
Education (reading, writing, counting)			
None	0		
Limited		15	
Fair			45
	0	35	100

The uses of the system, as well as its practical value, are easily assessed from a study of the cases themselves.

As regards the brain, the technical procedure included injection through the orbits, as soon after death as possible, of a 10 per cent. solution of formol saline, with removal of the brain at the earliest opportunity. After further hardening, one cerebral hemisphere was specially preserved and mounted for macroscopic study, including dioptrographic tracings, and the other retained for microscopic investigation.

APPENDIX II

Planimeter Areas of Brain in Square Inches

No. of case	Parietal	Occipitotemporal	Frontal	Total brain
1	3·44	9·53	6·39	19·38
2	1·95	6·87	6·87	15·69
3	4·14	7·83	7·36	19·38
4	3·50	8·30	7·91	19·69
5	2·93	6·20	4·54	13·67
6	3·79	6·50	7·03	17·35
7	4·44	7·46	6·18	18·06
8	2·47	6·30	5·86	14·63
9	3·37	8·15	7·91	19·40
10	4·05	7·77	7·90	19·72
11	4·60	8·82	6·91	20·31
12	3·54	7·49	6·70	17·75
13	3·22	7·06	5·30	15·58

PLANIMETER AREAS OF BRAIN IN SQUARE INCHES—*Continued*

No. of case	Parietal	Occipitotemporal	Frontal	Total brain
14	3·33	7·17	5·84	16·31
15	5·04	7·33	8·25	20·62
16	2·98	6·07	5·92	14·96
17	3·16	6·24	6·39	15·79
18	3·33	8·01	7·14	18·46
19	3·00	11·63	8·06	22·69
20	3·38	7·62	6·52	17·51
21	3·10	7·73	6·11	16·91
22	4·57	8·87	8·54	22·07
23	3·83	7·09	6·62	17·55
24	4·82	8·97	8·18	21·93
25	4·93	9·09	7·80	21·82
26	3·08	6·80	5·43	15·31
27	3·90	7·80	7·02	18·70
28	3·37	9·45	8·16	20·97
29	4·36	8·12	7·05	19·51
30	3·67	7·28	5·65	16·60
31	3·57	6·62	5·58	15·76

NOTE.—For check purposes the total brain area was recorded separately from the three which make it up; there is, therefore, an occasional slight difference of not more than 0·03.

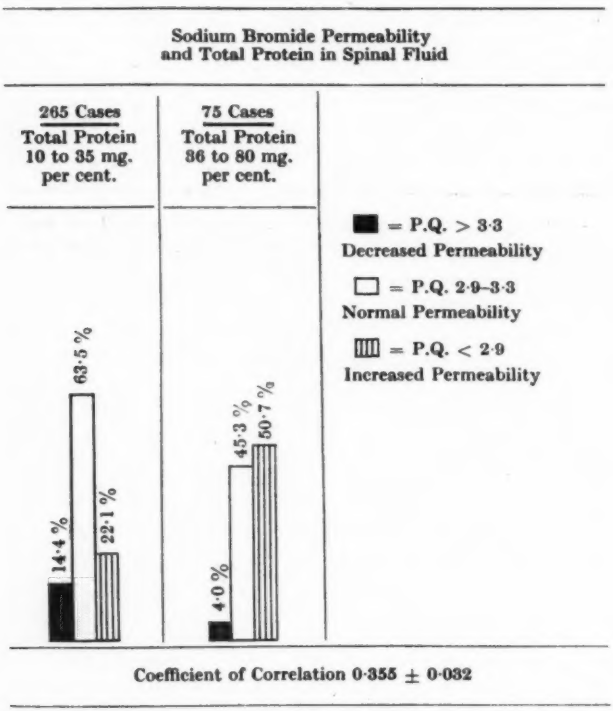
I. BARRIER PERMEABILITY TO BROMIDE AND PROTEIN CONTENT OF THE CEREBROSPINAL FLUID*

By

S. KATZENELBOGEN, Baltimore

The object of our previous studies on the distribution of bromide and calcium between blood and cerebrospinal fluid was to investigate the function of the barrier between blood and cerebrospinal fluid in various mental diseases.†

CHART I



* From the Laboratory of Internal Medicine, Henry Phipps Psychiatric Clinic, Johns Hopkins Hospital.

† *American Journal of Psychiatry*, 1931, **10**, 1043; 1932, **11**, 9.
Journal of Nerv. and Mental Diseases, 1932, **75**, 143; 1931, **74**, 636.
Annals of Internal Medicine, 1932, **5**, 1168.

The data secured by these studies were used in discussion of the diagnosis and pathogenesis of mental diseases; they were not expected to throw light on the mechanism of the function designated as barrier permeability. The latter obviously depends upon at least the following three factors: (*a*) the status of the structures constituting the barrier; (*b-c*) the physicochemical constitution of both blood and cerebrospinal fluid.

In this communication we are essentially interested in the problem whether or not there is any relationship between the protein content of the cerebrospinal fluid and the barrier permeability, as determined by bromide quotients (Walter's test).

Both the barrier permeability to bromide and the total protein content of the cerebrospinal fluid were determined in 340 cases of various mental diseases. The results obtained are summarized in two charts:

Chart I includes 265 cases with total spinal fluid proteins ranging between 10 and 35 mg. per cent., and 75 cases with protein values from 36 to 80 mg. per cent. While in the first group the barrier permeability is increased in 22·1 per cent. of the 265 cases, in the second group the permeability is increased in 50·7 per cent. of the 75 cases. In each of the two groups, however, the percentage of cases with normal permeability is markedly high; there is also in each group a small number of cases with low permeability.

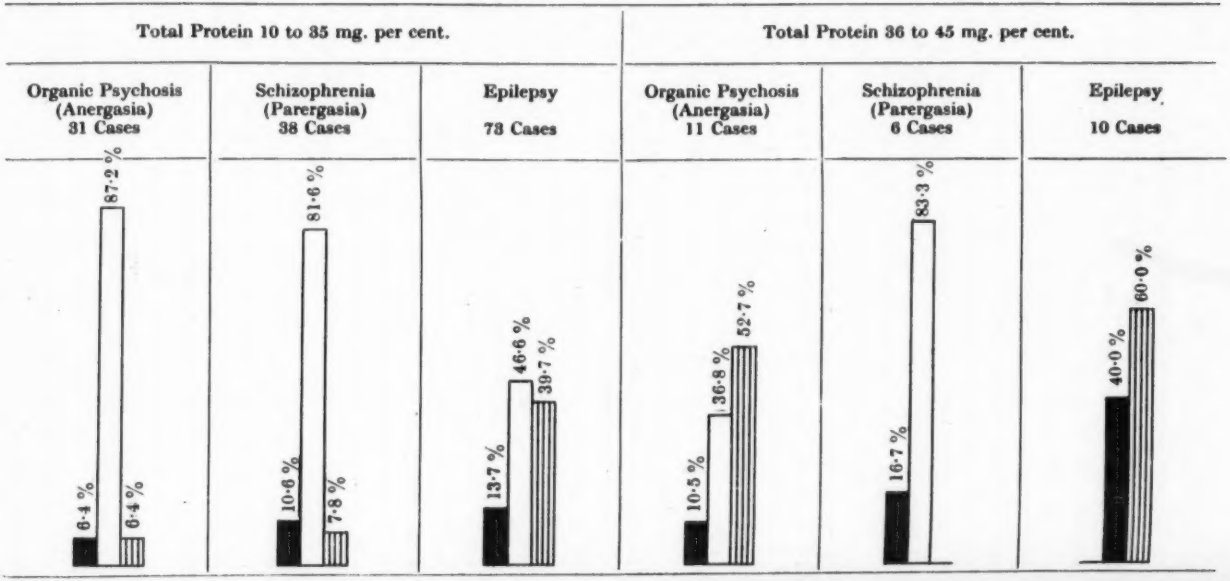
Chart II contains three types of disease, each one subdivided into two groups, according to the total protein content of the cerebrospinal fluid. In the organic psychosis group of 31 cases, with protein values from 10 to 35 mg. per cent., increased permeability is present in 6·4 per cent.; in 11 cases of the same group but with protein contents ranging between 36 and 45 mg. per cent. the permeability is increased in 52·7 per cent. In 73 cases of epilepsy with protein concentrations from 10 to 35 mg. per cent. the permeability is high in 39·7 per cent.; and in 10 cases with protein contents from 36 to 45 mg. per cent. the permeability is high in 60 per cent. In schizophrenia, while the group of 38 cases with low proteins contains a high permeability in 7·8 per cent., there are no cases with high permeability in the group with high proteins. Attention should be paid, however, to the small number of cases (6) in the last mentioned group. It is significant that in epilepsy there is a relatively high percentage of cases with high permeability in the series of cases with low protein contents. It is furthermore noteworthy that in each type of the diseases there are high percentages of cases with normal permeability in both the group of cases with low protein values and the group of cases with high protein values.

Our results show that the relationship between the content of spinal fluid protein and the barrier permeability to bromide is such that high spinal fluid protein and high barrier permeability often go together. That high protein in spinal fluid, however, is only a contributing factor in the determination of high barrier permeability is suggested by our findings in epilepsy and schizophrenia.

CHART II

Sodium Bromide Permeability and Total Protein in Spinal Fluid

■ = P.Q. > 3·3 Decreased Permeability
□ = P.Q. 2·9–3·3 Normal ,,
▥ = P.Q. < 2·9 Increased ,,



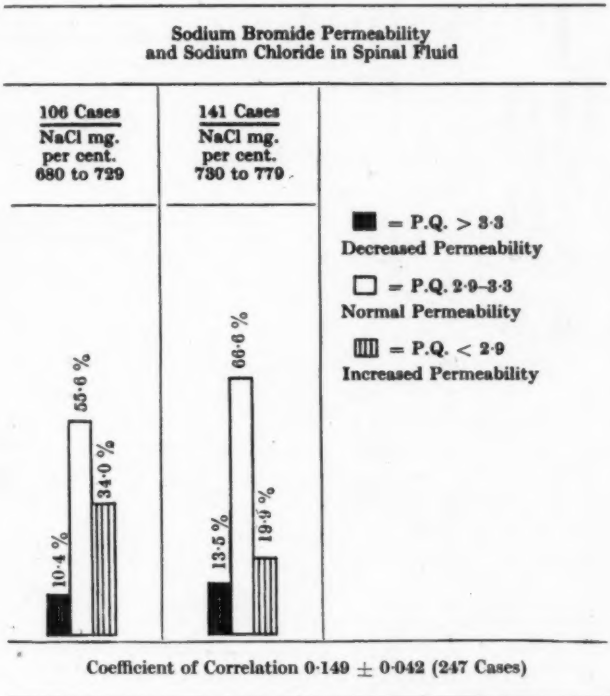
II. BARRIER PERMEABILITY TO BROMIDE AND SODIUM CHLORIDE CONTENT OF THE CEREBROSPINAL FLUID*

By

S. KATZENELBOGEN, Baltimore

The investigation was carried out in 247 cases of various psychotic reaction types. Chart I demonstrates that in 106 cases with sodium chloride contents ranging between 680 and 729 mg. per cent. the barrier permeability (determined by Walter's bromide test) is above normal in 34 per cent.; that in 141 cases with chloride contents varying from 730 to 779 mg. per cent. the barrier permeability is above normal in 19·9 per cent.

CHART I



* From the Laboratory of Internal Medicine, Henry Phipps Psychiatric Clinic, Johns Hopkins Hospital.

CHART II

Sodium Bromide Permeability and Sodium Chloride in Spinal Fluid

■ = P.Q. > 3·3 Decreased Permeability
□ = P.Q. 2·9–3·3 Normal ,,
▥ = P.Q. < 2·9 Increased ,,

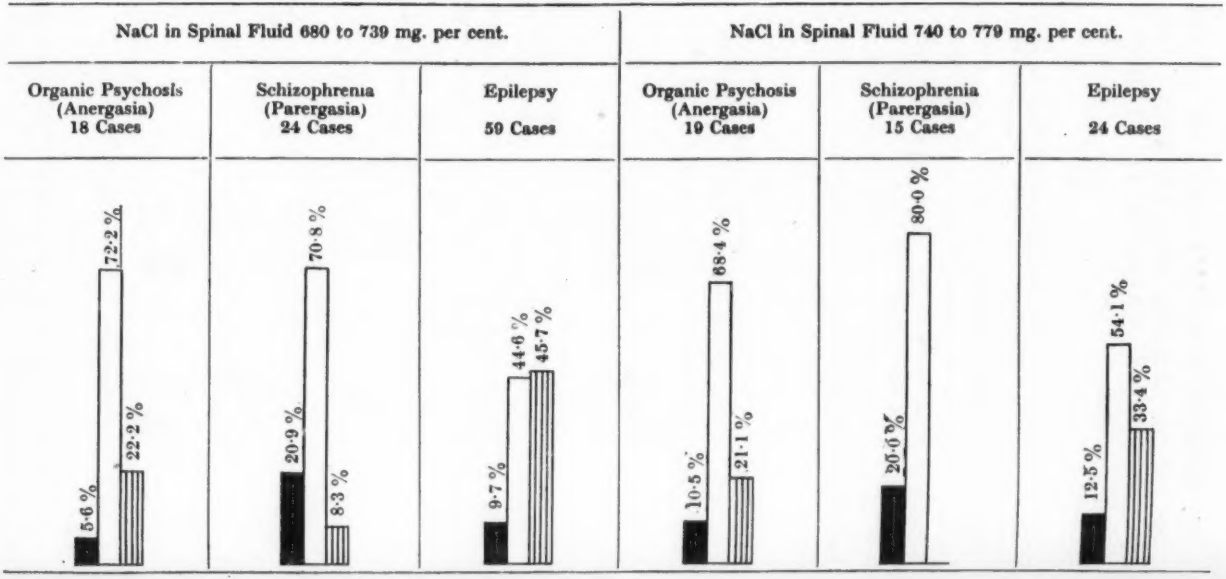


Chart II presents our findings in organic psychosis, schizophrenia and epilepsy ; in each of these psychotic types the cases are subdivided into two groups, according to the sodium chloride content of the cerebrospinal fluid. The chart shows that neither in organic psychosis nor in schizophrenia is the distribution of cases with normal, low and high permeabilities markedly affected by the spinal fluid chloride concentration. In epilepsy the series of cases with relatively high chloride values contains a lower percentage of cases with high permeability than the group of cases with comparatively low chloride contents.

From these results we infer that in Walter's bromide test the chloride content of the cerebrospinal fluid, like the protein content, is only a contributing factor in the determination of the distribution of bromide between blood and cerebrospinal fluid.

Editorial

THE FUTURE OF PSYCHOPATHOLOGY

PSYCHOPATHOLOGY, using the term in the sense of a psychological approach to the problems of the causation and mode of production of disease, is a subject of comparatively recent growth. Indeed, although its roots lie farther back, it cannot be said to have established any claim to incorporation in the field of science before the work of the French psychologists at the end of last century, notably the researches of Pierre Janet. Since that time, however, its growth has been rapid, and it has now become a wide-spreading tree with many branches. This later development has been dominated by the methods and theories of Freud, which have indubitably influenced to a greater or less extent all other workers in this field, although only a comparatively small number accept his views and principles in their entirety.

It cannot be denied that the work of the psychopathologists has enabled us to acquire a better understanding and control of certain disorders, notably the psychoneuroses. Nevertheless, there are features in the position of psychopathology to-day which arouse some disquietude and even bewilderment. It includes within its borders a number of schools of thought, divergent from one another not merely in details of method but in fundamental principles, each confidently putting forward conceptions in explanation of the same phenomena which are radically irreconcilable with one another. This divergence and irreconcilability no doubt are less profound than they appear at first sight to be, and many common features can be discerned when the matter is closely investigated, but the differences are clearly greater than can be found within the borders of any other subject claiming to follow the method of science.

It can easily be understood, therefore, that certain critics have turned from an enthusiastic contemplation of the spread and luxuriant foliage of the tree to an examination of the roots and soil upon which it is based, and have questioned whether these are solid and capable of supporting the structure which has grown from them. Such criticism can be directed to two fundamental points, which must be carefully distinguished from one another. In the first place it may be questioned whether

it is even possible to construct scientifically valid psychopathological conceptions, that is to say, whether the fundamental postulate of psychopathology—that behaviour and the sequence of conscious processes can be adequately resumed in formulæ couched in psychological terms and yet fashioned according to the rules of scientific method—is valid or false. In the second place, it may be asked whether, if such conceptions are possible, the conceptions which psychopathology actually puts forward have in fact been constructed by the use of scientific method, that is, by the observation of phenomena and the formation of formulæ resuming these phenomena and verifiable by the testing of further phenomena.

Dr. E. Mapother, in a witty and entertaining presidential address to the Section of Psychiatry of the Royal Society of Medicine, answers both these questions with an emphatic negative. He makes a vigorous onslaught upon the whole structure of psychopathology, and affirms not only that its methods are unsound, but that its basic principles are false and essentially incompatible with scientific method. He holds that the determining quality of conscious purpose, which is clearly a fundamental postulate in the psychologies of Freud and the other schools which have diverged from him, is completely illusory, that behaviour cannot be explained by conceptions constructed in psychological terms, that consciousness is nothing but awareness of happenings in our own body, and hence that formulæ by which science may hope to resume sequences of conscious phenomena can only be established in terms of those happenings. For him the ' psychological determinism ' of Freud is not the determinism of scientific method, and he regards the concepts of psychopathology as necessarily linked with the acceptance of animism and free-will.

All these are highly debatable propositions, largely dependent upon philosophical preconceptions, and in his endeavour to eradicate what he evidently feels to be a canker at the heart of psychiatry Dr. Mapother has used a bludgeon in a field where a rapier would be more effective. After all, science is only a special application of the inductive method, its particularity consisting in the requirement that the inductions must be verifiable, and capable of leading to the prediction and control of future phenomena. It is questionable whether the attempt to impose further limitations on this definition, and to insist that the application of scientific method to new fields should always conform to limitations which have proved successful in very different fields, will not hinder progress. One

is reminded of Planck's distinction between purist and pragmatic scientists. The former ' strive always after a perfect co-ordination of the accepted axioms of their science,' while the latter ' try to amplify the accepted first principles by the introduction of new ideas and thus send out feelers in all directions for the purpose of making progress.' It is surely possible that such amplification may take the form of endeavouring to construct formulæ in psychological terms to resume the sequence of phenomena constituting human behaviour while holding fast to the requirement that the process shall be governed by the rules of scientific method.

Dr. Mapother is on surer ground in his criticism of the actual achievements of psychopathology, and when he is contending not that they intrinsically cannot, but that they in fact do not, satisfy the requirements of scientific method. He recapitulates the objections of former critics to Freud's psychoanalytic procedure, the privacy of the observations, so that the phenomena cannot be publicly verified, and the possibility of distortion owing to the peculiar circumstances of the investigation. These objections seem to be valid, and to reduce Freud's method to a level definitely below that required by science. Privacy of observation is probably inevitable in the recording of certain ranges of behaviour, but verifiability, and elimination or estimation of the personal equation, are essential factors in scientific method. Unless, however, we are to adopt the position that such ranges of behaviour are forever incapable of scientific investigation, we may hope that by further refinement the distorting factors will be capable of recognition and assessment, and in the meantime only accept generalizations built upon observation of this kind with the utmost caution, and a full understanding of the possibilities of error.

Dr. Mapother further puts forward caustic but salutary criticism of the tendency of some psychopathologists to construct concepts which are nothing but invented entities whose sole function is to produce the phenomena they are invoked to explain. The arbitrary postulation of ' instincts ' and their reification as ' causes ' responsible for behaviour is an example in point. Certain psychopathologists have undoubtedly merited castigation in this respect, but it is probably not legitimately applicable to the concepts which Freud uses, however vulnerable these may be on other grounds. It is unlikely that any competent psychoanalyst would deny that such concepts as ' complex,' ' id ' and ' ego ' are merely convenient symbols for formulating the routine of experience, and

that they are not to be regarded as subsisting spiritual entities whose activities are conditioned by free-will. The constant and careful recognition of this point, however, upon which Dr. Mapother insists, will no doubt tend to curtail the extravagant weaving of flimsy abstractions to which psychopathologists are sometimes addicted.

Lastly, Dr. Mapother urges that there must be continuity between neurology and psychiatry, and that endeavour should be concentrated upon extending to higher levels of human activity the concepts which are in contact with the whole biological field, and which neurology has found to be fruitful in understanding lower levels of activity. There can be no question that this aim is laudable and that it should be persistently pursued, but this does not mean that attempts must not be made to formulate the experiences of these higher levels by the aid of conceptions which may be more easily applicable to their peculiar nature. In the present state of our knowledge formulæ couched in psychological terms can resume sequences of behaviour and speech which are as yet inaccessible to any profitable neurological approach, and surely therefore such formulæ can be legitimately constructed. Naturally this does not imply that the march of neurological knowledge may not ultimately embrace these processes in formulæ applicable to the whole biological field, and therefore more general and fundamental. Nor does the use of psychological conceptions involve postulating the entire independence of a mental series of phenomena from all others, but only that certain ranges of human activity are at present formulated most profitably in psychological terms.

It is certainly desirable that psychopathology, when it devises concepts to resume the phenomena which it oberves in its special sphere, should have due regard to the concepts which neurology has formulated to resume analogous phenomena at lower levels of activity, and endeavour to advance along a line consonant with a wider biological application. Dr. Emanuel Miller, in his presidential address to the Medical Section of the British Psychological Society, has emphasized this principle, and pointed out that it may be feasible to winnow the vocabulary of psychopathology and to do away with many terms which have already their analogues in biology and neurology, the latter being better terms because they are applicable over a wider field.

The multiplicity and diversity of schools in which psychopathology, like psychology itself, has an unenviable pre-

eminence, and the dispute of opinion regarding its methods and fundamental principles, make it difficult to forecast its future. It is conceivable that the failure of many of its later developments adequately to satisfy the demands of scientific method, and a more rigid insistence upon the verifiability which is the corner-stone of that method, may lead to a pruning of over-ambitious flights, a return to the level of Janet's epoch-making researches, with the methods of which no scientist can quarrel, and a renewed attempt to build a higher structure thereon. It is probable, however, that the future of psychopathology will be determined, as always in the history of science, by its workers and their achievements rather than by its critics.

Abstracts
Neurology

NEUROANATOMY AND NEUROPHYSIOLOGY

[1] **The choroidal structure in vertebrates** (Le formazioni coroidee nei vertebrati).—M. VIALLI. *Riv. di pat. nerv. e ment.*, 1934, **43**, 573.

THIS is a most elaborate study of the subject, extending over 372 pages, with 45 pages of bibliography. The author studies the anatomy and physiology of the choroid plexus in numerous examples of every family of vertebrates under the following headings:

I. Morphology of the choroid structure.
The various types of choroid structure.
Topographical distribution of choroid tissue.
The comparative anatomy of the choroid plexus.
Distribution of vessels in the plexus; the communication between the extra- and intraventricular fluid in different vertebrates.
II. The histology and histophysiology of the choroid plexus.
Epithelium.
Connective tissue.
Vessels.
Nervous tissue in the choroid plexus.
III. Morphology and physiology of the ependymal and meningeal structure.

It is clear that such an article is mainly useful for reference, but anyone interested in the subject can hardly fail to find the information he wants either in the text or in the literature referred to.

R. G. G.

[2] **The effect of section of the corpus callosum on the motor performance of monkeys.**—M. A. KENNARD and J. W. WATTS. *Jour. Nerv. Ment. Dis.*, 1934, **79**, 159.

THE authors find that section of the corpus callosum in monkeys produces no motor weakness and does not cause forced grasping, but gives rise to a definite syndrome characterized by inertia and slowness in initiating purposeful movements.

Section of the corpus callosum subsequent to unilateral lesions of the motor areas produces no additional motor deficit in the contralateral extremities.

A unilateral lesion of the motor or premotor areas subsequent to section

of the corpus callosum is followed by no greater deficit than that seen with the same lesion with corpus callosum intact.

Ipsilateral movement from stimulation of area 6 is not abolished by section of the corpus callosum.

R. G. G.

[3] **Ligation of the anterior cerebral artery in monkeys.**—J. W. Watts. *Jour. Nerv. Ment. Dis.*, 1934, **79**, 153.

Ligation of the unpaired anterior cerebral artery of the monkey at the genu of the corpus callosum produced no neurological signs either in young or mature specimens. Likewise, occlusion of the main trunk peripheral to this or of individual branches failed to produce impairment of function. At autopsy the brains of these animals showed no gross evidence of lack of blood supply over the distribution of the anterior cerebral artery.

Coagulation of as many as four or five of the largest superior cerebral veins produced no disturbance of function.

Though primary occlusion of the anterior cerebral artery in Macaca mulatta produces no symptoms, impairment of function may occur when it is associated with a hypothalamic lesion. A possible explanation of this may be the low blood pressure resulting from destruction of this region of the brain. Under such conditions, the collateral circulation supplied by the middle cerebral artery is probably inadequate. That circulation in some cases was obviously poor is indicated by their frequent advanced age, mental deterioration and histories of numerous cerebral accidents confirmed by the presence of two to four areas of cerebral softening at autopsy. However, it is not suggested that the anterior cerebral artery of man should be ligated without due consideration and it would seem particularly hazardous to do so at a time when the blood pressure is low.

R. G. G.

[4] **Cerebral circulation. XXXV. The comparative effect of ergotamine tartrate on the arteries in the pia, dura and skin of cats.**—J. L. Pool and G. I. Nason. *Arch. of Neurol. and Psychiat.*, 1935, **33**, 276.

Owing to the fact that ergotamine tartrate has been found to be one of the most effective substances in the treatment of the headache of migraine, a series of experimental studies has been undertaken with a view to obtaining more information concerning the mechanism by which relief is afforded. The effects of the intravenous administration of ergotamine tartrate on anæsthetized cats may be summarized as follows: (1) inconstant effects on the calibre of the pial arteries; (2) constriction of the dural arteries, the average decrease in diameter being 25 per cent.; (3) constriction of the arteries of the skin (average 39 per cent.); (4) elevation of the systemic

arterial pressure; (5) elevation or no change in the cerebrospinal fluid pressure; (6) alteration in the venous pressure similar to that of the cerebrospinal fluid pressure; (7) decrease in the pulse rate.

Evidence from various sources suggests that the headache of migraine may be caused, in part, by the dilatation of the arteries in the dura.

R. M. S.

NEUROPATHOLOGY

[5] **The true pathology of infantile amaurotic idiocy** (Über die wahre pathologischen Natur der infantil-amaurotischen Idiotie).—K. Schaffer. *Deut. Zeits. f. Nervenheilk.*, 1934, **135**, 11.

Two periods may be differentiated in the investigation of infantile amaurotic idiocy. During the era which may be termed the 'morphological' it was established that in this disease exclusively the ganglion-cells are damaged as they arise from the neuro-ectoderm. The meninges and blood-vessels which originate from the mesoderm are unaffected; similarly, the organs of metabolism, the spleen, the liver and the bone-marrow are not involved. For these reasons Schaffer is convinced that amaurotic idiocy is the result of an affection of the ectoderm. Other authors, however, do not agree with this view. In cases of so-called Gaucher's and Niemann-Pick's diseases, the same changes have been observed in the brain as in amaurotic idiocy. For this reason some writers suppose that all these affections are identical. In cases of Gaucher's and of Niemann-Pick's diseases definite alterations have been observed in the organs of metabolism. Kufs has said that all the contrary arguments advanced by Schaffer do not affect the conception of amaurotic idiocy as a local phenomenon of disordered metabolism of colloids and lipoids. In accordance with Kufs, Spielmeyer maintains that amaurotic idiocy is a lipoidosis of the type of Niemann-Pick's disease.

Schaffer terms the second era the 'chemical era.' By chemical investigations Epstein found that in the brain of a case of amaurotic idiocy the quantity of lecithin and kephalin was diminished in comparison with that of a normal brain; while in the brain of a case of Niemann-Pick's disease the quantity of lecithin and kephalin was about double that in a normal brain. From this result Epstein concludes that cases of pure amaurotic idiocy and of Niemann-Pick's disease are different entities. Schaffer, therefore, considers that his opinion is confirmed.

M.

[6] **A case of 'status marmoratus' involving the thalamus** (Über das Vorkommen des Status marmoratus im Thalamus opticus).—R. Holzer. *Zeits. f. d. g. Neurol. u. Psychiat.*, 1934, **151**, 696.

The case described is that of a mentally backward boy suffering from involuntary movements of the upper and lower limbs which dated from

birth. He died from scarlet fever at the age of four years. A condition of typical 'status marmoratus' was found in the putamen and also in the thalamus of both sides. The author considers that the fundamental cause of the condition was an inborn weakness in the basal grey matter of the central ganglia. As a result of either an endogenous or exogenous cause, changes may arise in the tissue of those regions which offer no resistance. The nature of the changes which finally cause a gliosis is not known.

M.

[7] **Multiple parathyroid tumours with massive mediastinal and subcutaneous hæmorrhage.**—R. B. CAPPS. *Amer. Jour. Med. Sci.*, 1934, **188,** 800.

A CASE is reported of multiple parathyroid tumours one of which gave rise to a massive mediastinal and subcutaneous hæmorrhage. The patient had no definite symptoms or signs of hyperparathyroidism, the complaints being related entirely to the hæmorrhage. The case proved fatal. At post-mortem examination on each side of the trachea at the level of the clavicle a nodule was found, the larger one measuring $7 \times 3{\cdot}5 \times 2$ cm. and weighing 22 gm. On incision it was found to be filled with blood which dissected the tumour tissue through the capsule and which was traced to all the subcutaneous and mediastinal hæmorrhagic areas. Histologically the parathyroid tissue examined proved to be identical with that of the cases of multiple parathyroid tumour described by Albright and his co-workers.

C. W. D.

[8] **Significance of blood groups in inoculation malaria.**—IRVING M. DERBY. *Amer. Jour. Psychiat.*, 1935, **91,** 881.

ON the basis of experimental and clinical observations on the relationship of blood groups to intravenously induced malaria, it is concluded that extravascular agglutination morphologically damages the plasmodium. Intravascular agglutination results in clinical reactions suggestive of plasmodial as well as cellular damage, and the possibility of embolism is noted. Reactions to inoculation, the time of incubation, the character of the fever produced, all depend upon a number of complicated factors, among which the donor-recipient relationship has a definite and appreciable effect. Corelationship of blood group is of no great importance in affecting successful infection, and is of little clinical interest in determining primary fever. Blood type plays no definite rôle in the improvement following malarial and antiluetic therapy in general paralysis. An 'agglutination injury' theory is proposed to explain the disappearance of gametocytes in inoculation malaria.

C. S. R.

[9] **Calcium content of the cerebrospinal fluid, blood serum and serum ultrafiltrate.**—J. J. Michaels and O. M. Searle. *Arch. of Neurol. and Psychiat.*, 1935, **33**, 330.

Among 80 patients with neuropsychiatric disorders in 18 different diagnostic groups there were no significant abnormal findings in regard to the calcium of the cerebrospinal fluid, the blood serum or an ultrafiltrate of the serum or in regard to the ratios of these quantities to each other.

R. M. S.

[10] **A note on a proteose-like substance in spinal fluid.**—Purcell G. Schube and Richard C. Whitehead. *Amer. Jour. Psychiat.*, 1934, **13**, 1083.

An ether-alcohol reaction in the spinal fluid is described. The end-product of this reaction is a flocculent material possessing the properties of a proteose-like substance. This substance is present in all spinal fluids examined.

C. S. R.

SENSORIMOTOR NEUROLOGY

[11] **Paralysis agitans and trauma.**—L. Grimberg. *Jour. Nerv. Ment. Dis.*, 1934, **79**, 14.

A survey of 86 cases reported in which trauma has preceded paralysis agitans. The author points out that since the syndrome is only a composite picture of symptoms due to involvement of the striato-pallidal system in addition to other regions of the brain, in the same manner as an aphasia or a hemianopsia may be the result of a tumour, a hæmorrhage, or a trauma, so may the Parkinsonian syndrome be the result of infection or trauma. However, a history of trauma alone, even if it occurred prior to the onset of the disease, is not sufficient. First, the trauma must be of sufficient severity to produce definite damage to the brain; secondly, the trauma must be directly to the head or, if not to the head, of such a nature as indirectly to involve the brain; thirdly, there must be a clear and definite developmental connection between trauma and disease.

The conclusions drawn are that :—

(1) A great majority of the cases were diagnosed on assumption of a hypothetical neuritis ascendens, which has no existence in fact.

(2) In a great number of cases, the history of trauma was not definite.

(3) In many cases, the time relationship between trauma and onset of diseases was of such length as to preclude connection between them.

(4) Many cases either were not paralysis agitans, or belonged to postencephalitic Parkinsonism.

(5) Only in two cases was there an intimate relationship between trauma

and disease, and the clinical picture was one of a Parkinsonian syndrome due to an injury of the brain.

(6) Trauma therefore cannot cause paralysis agitans.

R. G. G.

[12] **Head injury. Neurologic and psychiatric aspects.**—Israel Strauss and Nathan Savitsky. *Arch. of Neurol. and Psychiat.*, 1934, **31**, 893.

Clinically, the organic sequelæ of head injury should be differentiated from the terror and anxiety reactions following a threat to bodily integrity. The term ' traumatic neurosis ' may be confined to the latter type of reaction. The subjective post-traumatic syndrome, characterized by headache, giddiness, inordinate fatigue on effort, intolerance to intoxicants and vasomotor instability, is organic and is dependent on a disturbance in intracranial equilibrium due directly to the blow on the head. It is suggested that the term ' post concussion syndrome ' be used for this symptom-complex. ' Traumatic encephalopathy ' may be used as a generic term if it is understood that it includes cases in which physiological disturbances of the cerebral mechanism are present although organic lesions are not demonstrable. Psychogenic factors always complicate the clinical picture if the socio-economic and other difficulties following the trauma last long enough. Negative results on neurological examination and a normal mental status are no final criterion of the presence, absence or degree of damage to the brain resulting from head trauma. No opinion should be formed in doubtful cases without a systematic clinical survey. It must be noted that failure to understand a clinical phenomenon is no proof of its psychogenicity and also that significant cranial injury can occur without loss of consciousness.

C. S. R.

[13] **Frontal lobe lesions with cerebellar manifestations.**—A. Gordon. *Jour. Nerv. Ment. Dis.*, 1934, **79**, 411.

Among various manifestations observed in lesions of the frontal lobe is one that has aroused controversy, viz. ataxia of cerebellar type.

Five cases are presented and the literature is reviewed. Evidence tends to prove that the frontal region of the cerebrum contains a centre for equilibrium and orientation and when the cellular elements of this centre are involved, even in a small degree, the fronto-ponto-cerebellar pathway originating therein is functionally disturbed and gives rise to ataxic manifestations simulating those of primary cerebellar disorders. From the standpoint of differential diagnosis, the multiple anatomoclinical and experimental cases cited above, as well as the five personal cases described here, indicate strongly that a bilateral irregular distribution of cerebellar phenomena (the dissocia-

tion phenomenon) may be of considerable assistance in localizing the original lesion in the frontal area of the brain. Strict unilaterality of morbid cerebellar manifestations is in favour of cerebellar lesions.

R. G. G.

[14] **Syndrome of a dorsal-pontine tumour** (Dorsal-pontine Tumersyndrom).—T. RASDOLSKY. *Zeits. f. d. g. Neurol. u. Psychiat.*, 1935, **152**, 530.

THE author examined five cases of tumour of the dorsal-pontine region. As regards diagnosis his conclusions are as follows: Difficulty in opening the mouth and dysarthria—speech being rather 'through the teeth,' with or without some contraction of the facial muscles—are usual. There may be no other sign of cerebral disturbance. Attempts at radical operation are useless in such cases. Right subtemporal decompression may be performed combined with drainage, a large opening being made in the anterior and inferior corner of the lateral ventricle in order to allow a free outflow of cerebrospinal fluid from the lateral and third ventricles.

M.

[15] **Cerebral emaciation** (Ein Beitrag zur zerebralen Magersucht).—H. STEFAN. *Münch. med. Woch.*, 1934, **81**, 1608.

EMACIATION is usually the result of organic disease, more especially of an endocrine organ (e.g. Grave's, Addison's and Simmond's diseases). More rarely it depends upon an organic affection of the brain, e.g. encephalitis lethargica, chronic manganese poisoning or general paralysis. In the latter diseases damage to the vegetative centres in the floor of the midbrain is said to be the cause of the emaciation.

M.

[16] **Herpes zoster cephalicus: Observations on 20 cases** (Herpes zoster cephalicus: zwanzig eigene Beobachtungen).—F. WIEGMANN. *Münch. med. Woch.*, 1934, **81**, 1970.

HERPES zoster affecting the cranial nerves was observed in 20 cases. A single nerve was affected in 11 cases, and two or more cranial nerves in nine. It has been supposed that involvement of the ganglion or of the peripheral nerve in addition to a meningitis is the lesion in a herpes zoster. All these different structures may be implicated, but a meningitis is invariably combined either with involvement of the ganglion or of the peripheral nerve. Infection, intoxication and mechanical irritation are of equal importance. Histologically, the disease is a neuritis differing from other forms of neuritis only in the presence of cutaneous vesicles. Hyperalgesia of the skin appearing at the onset is of much value in the differential diagnosis.

M.

[17] **Scapular tendon reflexes.**—S. M. WEINGROW. *Jour. Nerv. Ment. Dis.*, 1934, **79**, 391.

SOME tendon and myotatic reflexes of the scapular region, heretofore unreported in the literature, are here presented.

These are different in reaction and innervation from the scapular reflex of Dejerine, since the cells governing them extend into the fourth and fifth cervical segments. The scapular tendon reflexes also differ from the scapular skin reflex of the literature. Hence, in speaking of scapular reflexes, one should always designate them as skin or tendon scapular reflexes. The motor cells concerned in the reflex arcs of the scapular reflexes are located in the fourth, fifth and sixth cervical segments, whereas those subserving almost all the tendon reflexes of the upper extremity are situated in the sixth, seventh and eighth cervical, and the first two thoracic segments. The scapular tendon reflexes do not seem to need reinforcement, since they are present in every normal individual. Deformities of the spinal column, tumours in the region of the scapula, and fractures of the bone may affect or interfere with the reactions of these tendon reflexes. Diseases of the brain, such as apoplexy and cerebrospinal syphilis, and diseases of the spinal cord, such as anterior poliomyelitis, multiple sclerosis, amyotrophic lateral sclerosis, etc., affect these tendon reflexes as they do the other tendon reflexes of the body. The reflexes are of particular value in differentiating cases of organic from hysterical hemiplegia or monoplegia, since the reactions are normal in the latter group.

In cases of postencephalitis and postencephalitic Parkinsonism the reflexes show marked differences in reaction. A case of dystonia musculorum deformans of five years' duration presented definitely unequal scapular reflex reactions. Some evidence has been shown of involvement of the levels through which the reflexes are mediated in the fourth, fifth and sixth cervical segments in the cord. Some cases of tabes dorsalis with definite absence of other tendon reflexes show present and active tendon and muscle reflexes in the scapular region. The reflexes are important in some cases where the diagnosis of syphilis of the central nervous system is uncertain. Instances of peripheral nerve trauma or infection in which the scapular tendon reflexes were affected are also presented.

R. G. G.

[18] **Paralysis of the brachial plexus after protective inoculation with antitetanic serum** (Plexuslähmung nach Schutzimpfung mit Tetanusserum).—D. RIDDER. *Münch. med. Woch.*, 1934, **81**, 1085.

A MAN sustaining a dirty wound was given an injection of antitetanus serum. Eight days later pyrexia appeared which at first was thought to be due to

influenza. On the following day a typical serum rash appeared with swelling of many joints, especially the right shoulder. The pain decreased during the next two weeks, but a typical paralysis of the right brachialis plexus was noticed. This persisted for two years before recovering. Only a few similar cases have been recorded. The cause of such a paralysis following antitetanic serum injection is not definitely known. Previous serum injections had not been given to this man. It is supposed that such cases are the result of individual predisposition.

M.

[19] **Complete recovery confirmed by histological examination in a case of post-vaccinial encephalitis** (Pathologisch-anatomisch gesucherte Ausheilung eines Falles von Encephalitis post vaccinationem).—B. HERKENRATH. *Zeits. f. d. g. Neurol. u. Psychiat.*, 1935, **152**, 293.

A GIRL was vaccinated for the first time when she was nearly two years of age. As no result was apparent she was revaccinated 18 months later. Seven days following the vaccination she developed signs of encephalitis. Complete recovery took place after three and a half weeks. Eighteen months later the child died of an acute illness. On complete histological examination of the central nervous system only unimportant remains of the encephalitis were found.

M.

PROGNOSIS AND TREATMENT

[20] **Lecithin treatment of some multiple sclerosis syndromes.**—M. H. WEINBERG. *Jour. Nerv. Ment. Dis.*, 1934, **79**, 264.

TWELVE cases of multiple sclerosis have been treated with intraspinal injections of lecithin in accordance with Minea's and Dragomir's method. Ten of these cases have been carefully studied before and after treatment. Nine of the ten showed greater or lesser improvement. Among these were several severe cases. The method is harmless, though rather severe on the patients in certain respects. In its entirety it consists of intraspinous lecithin injections, the administration of cod-liver oil over long periods of time, and also of quinine hydrochloride.

The theoretical grounds for the success of the treatment from the author's standpoint are that the lecithin neutralizes the lipolytic substance present in the spinal fluid.

The results are sufficiently good to justify further use of this method.

R. G. G.

Psychopathology

PSYCHOLOGY

[21] **Perseveration and personality.**—Kenneth H. Rogers. *Jour. of Ment. Sci.*, 1935, **81**, 145.

Contemporary with the experimental determination of perseveration as a mental function, there have been effected correlative explorations of the possible relationships between this function and personality features. Spearman has indicated that the so-called 'type' psychology bears on this problem, and perseverative function as a common basic feature of these various personality dichotomies is suggested. Certain investigations would appear to have established a definite relationship between perseveration and personality characteristics. Apart from intelligence, perseveration offers one of the more important contributions toward the delineation of individual differences on a functional basis.

C. S. R.

[22] **Perseveration and personality: some experiments and a hypothesis.**—Raymond B. Cattell. *Jour. of Ment. Sci.*, 1935, **81**, 151.

From experimental observations, two hypotheses are suggested to account for the facts. One is that perseveration is essentially an indication of nervous debility—high perseveration indicating nervous exhaustion. In agreement with this, lack of initiative, absent-mindedness, dreamy contemplative outlook, and a frequent history of illness are found in such types. No difference, however, could be discovered in the number of hours of sleep required by low and high perseverators. The other hypothesis is that high perseveration is an indication of conflict, discouragement and inhibition induced in early life. The temperament traits of low perseverators seem to arise from a somewhat strict discipline and supervision. The child who is brought up in a framework of consistent strict and objective discipline is less likely to suffer from emotional conflict and frustration than the child who lives in a lax but emotional and inconsistent home atmosphere. One can suppose that a person's perseveration score at any moment depends upon three things: (1) racial hereditary endowment, (2) degree of general fatigue, (3) amount of deep frustration incurred in emotional development. By 'deep frustration' is meant frustration of some major instinct, particularly the self-assertive instinct, not occurring at a fully conscious level, which may no longer be caused by environment itself, but may be the product of conflict (discouragement and an ensuing deadlock of impulses) engendered by the environment of early childhood. The character failings of the low perseverator are those arising from inadequate inhibition and thoughtfulness, those of the high perseverator from too profound conflict and discouragement.

C. S. R.

PSYCHOSES

[23] **Encephalographic studies in manic-depressive psychosis.**—MATTHEW T. MOORE, DAVID NATHAN, ANNIE R. ELLIOTT and CHARLES LAUBACH. *Arch. of Neurol. and Psychiat.*, 1934, **31**, 1194.

IN a previous communication, in which encephalographic studies of 60 schizophrenic patients were reported, the conclusions indicated that definite organic changes existed, as manifested by the failure of any encephalographic study to reveal a normal cerebral pattern. Here is presented the results of a similar study of 38 cases of manic-depressive psychosis in various stages. It was found that the cerebrospinal fluid pressures were in the majority of cases top normal or higher, indicating the presence of the factor of chronic increased intracranial pressure. The quantity of cerebrospinal fluid removed in the majority of cases indicated varying degrees of cortical atrophy and enlargement of the ventricular system and cisterns. No definite cerebral pattern was obtained in a sufficient number of cases to be characteristic. The encephalographic pathological condition was manifested in the following ways: (1) cortical atrophy of varying intensity; (2) enlargement of the ventricular system; (3) asymmetry of the lateral ventricles; (4) absence of cortical air markings; (5) enlargement of the cisterns; (6) island of Reil atrophy; (7) enlargement of the sulcus callosi and sulcus cinguli; (8) increased interhemispheric air, and (9) cerebellar atrophy. In fact none of the encephalographic films showed a normal cerebral pattern.

C. S. R.

[24] **Crimes of unintelligible motivation as representing an initial symptom of an insidiously developing schizophrenia.**—A. W. HACKFIELD. *Amer. Jour. Psychiat.*, 1935, **91**, 639.

THIS study is based on a series of 32 capital criminals who have come under observation at the University of Zürich Psychiatric Clinic. They are divided into three groups: (1) those who committed their crime while suffering from a latent or manifest schizophrenia but were sentenced to prison; (2) similar schizophrenic criminals who were treated medically; (3) criminals diagnosed as psychopathic personality of the moral insanity type who were declared responsible for their acts and sent to prison. It has been shown that the stress of prison life had a deleterious effect upon the psychoses of patients in group (1); in all of them the psychosis progressed and they require permanent commitment. As for group (2), 76·9 per cent. of the cases have shown good remissions and are living outside of an institution, most of them remaining under medical supervision; in not a single instance did the hardships of prison life precipitate a psychosis in the cases of group (3). The conclusion is that during the prodromal state of an insidiously developing schizophrenia, persons previously socially and economically adjusted may commit atrocious crimes; usually these acts are of an unintelligible motiva-

tion. Such crimes, when committed by a person who discloses primary schizoid tendencies, are symptomatic of a latent schizophrenia. From a medico-legal standpoint such criminals must be regarded in the same light as if suffering from a manifest psychosis; if such cases are sent to prison they react as unfavourably to prison life as do cases of manifest schizophrenia.

C. S. R.

[25] **Blood bromine in the psychoses.**—T. J. HENNELLY and E. D. YATES. *Jour. of Ment. Sci.*, 1935, **81**, 173.

OVER short periods the blood bromine of 15 normal and 45 psychotics was studied. It was found that in normal males it varies between 0·6 and 2·0 mg. per cent., while in normal females there was a wider variation at the lower levels, falling to 0·25 mg. per cent. in one instance. Of the male psychotics examined, low values were found indiscriminately in all types of schizophrenia, in paraphrenia, manic-depressive psychosis and involutional melancholia. One case of oligophrenia gave consistently low values. Psychoneurotics and organic dements gave values within the normal range. No correlation was observed between changes in mental state and variations in blood bromine. Its estimation, too, is of little value in the differential diagnosis of the manic-depressive psychosis. Individual blood bromine variations are endogenous in character, and are attributed to fluctuations in distribution of bromide between the blood and the tissues.

C. S. R.

[26] **A pharmacodynamic investigation of the autonomic nervous system in schizophrenia.**—H. FREEMAN and H. T. CARMICHAEL. *Arch. of Neurol. and Psychiat.*, 1935, **33**, 342.

IN 24 normal male subjects and in 72 schizophrenic patients free from detectable organic disease, the reaction of the blood pressure and the pulse rate to the intravenous injection of 0·05 mg. of epinephrine was investigated. The following results were obtained :—

(1) The maximum change in blood pressure and pulse rate was attained within the first minute after injection.

(2) The mean rise in systolic pressure in the schizophrenic patients was 43·8 mm. and in the normal subjects, 56·2 mm. The difference between these two values is statistically significant and indicative of a diminished reactivity to the drug in the psychotic group.

(3) In the case of the diastolic pressure, the reaction was quite variable, and the mean change in both patients and normal subjects was slight. There was, however, a greater tendency for the patients to show a rise in the diastolic pressure.

(4) In the patients the mean increase in pulse rate was 13·6 beats per

minute and in the normal subjects, 16·3 beats. The difference is not significant, but in the distributions the patients showed a greater diversity of response and, in some cases, a slowing of the rate. This may possibly be attributed to the existence of a strong vagal tonus.

(5) No correlation was found between the extent of the reaction and the initial levels.

(6) No correlation was found between the reaction to epinephrine and the rate of oxygen consumption, nutritional index, schizophrenic subclass, psychiatric status or emptying time of the colon. Age apparently had a slight effect in lessening the total degree of response.

(7) No characteristic syndrome of autonomic imbalance—including the levels of blood pressure, pulse rate, basal metabolism and the emptying time of the colon—was found in schizophrenia.

(8) Before the injection of epinephrine, the systolic and diastolic pressures in the patients exhibited a fair degree of relationship, the correlation coefficient being 0·57. After the injection of epinephrine, the association was almost totally disrupted, the coefficient being practically zero.

R. M. S.

[27] **The concomitance of organic and psychological changes during marked improvement in schizophrenia.**—MILTON H. ERICKSON. *Amer. Jour. Psychiat.*, 1934, **13**, 1349.

DETAILED psychiatric, psychological and physiological studies were made for seven months on a schizophrenic-catatonic reaction type. Three distinct psychiatric states—stupor, recovery from the stupor, and a condition of apparent recovery from the psychosis—were found, for each of which a physiological cross-sectional study was made. During the stupor the patient was under weight, had diminished oxygen consumption, reduced body temperature, polyuria and delayed colonic emptying time. Other findings were normal. During the second period he gained weight, showed a slight equivocal decrease in his oxygen consumption rate, a slight increase in body temperature, mild secondary anæmia, a questionable low blood volume and low venous and arterial oxygen content. During the third period the patient appeared to have reached his pre-institutional state, had gained weight, had a normal oxygen consumption rate, with normal body temperature. Except for a marked polyuria and low venous oxygen content, the physical data showed no apparently significant deviation from the normal. There was evidence suggestive of a pituitary deficiency manifested about puberty and also during the first and third periods of study. However, the fluctuations noted could likewise be attributed to an abnormal functioning of the hypothalamus. Coincidental with the psychiatric and psychological changes there were corresponding or opposite fluctuations and variations in the organic sphere. Also, in some instances, an apparent independence has

been indicated by physiological constancy. More studies of this nature may tell us much about the question of functional interdependence.

C. S. R.

PSYCHOPATHOLOGY

[28] **Hypothyroidism and cretinism in childhood.**—I. P. Bronstein and Andrew W. Brown. *Amer. Jour. Orthopsychiat.*, 1934, **4**, 412.

Twenty hypothyroid children of various types who were being actively treated with thyroid extract were given repeated psychological tests over a period from one to five years to determine by quantitative measurements both the amount and nature of their mental growth. There was evidence that early recognition and persistent treatment thereafter was the important factor in ultimate mental development. All cretins if treated are not predestined to a fixed low mental age. Some of them may reach at least a mental age of 12 years. Most of these children have intelligence ratings between 50 and 70 and if treated will probably have at maturity a mental age between seven and nine years. Some cretins continue to show growth up to 14 years of age. Whether the increment of intellectual growth is constant throughout the entire growth period can be determined only by following these cases over a longer period of time. Children who have normal birth and developmental histories but who develop thyroid deficiency later in life following a specific or a series of non-specific infections (juvenile hypothyroidism) progress successfully mentally if properly treated.

C. S. R.

[29] **Endocrine studies in mental cases.**—Myer M. Harris, William A. Horwitz, and Siegfried E. Katz. *Psychiatric Quarterly*, 1934, **8**, 655.

A group of mental patients was investigated regarding the effect of the administration of antuitrin-S and also of emmenin. The latter had no notable clinical effect. The giving of the former was followed by immediate improvement in only a few of the cases and it was therefore impossible to decide whether this was merely a concomitant occurrence. Its prolonged administration did not interfere with the regularity of the menstrual cycle in those who had normal cycles when the medication was started. In some cases of secondary amenorrhœa the menses returned and usually the mental state improved as well. In one case of spontaneous menopause with amenorrhœa of several years' standing there was a return of a menstrual period during antuitrin-S administration. In only one of the males with undescended testes did it appear to bring about an enlargement of the gonads with a tendency to descend towards the scrotum. None of those who had hypogenital development showed any change in their mental state and at no time did antuitrin-S produce any consistent acute effect on the metabolic rate.

C. S. R.

Reviews and Notices of Books

Neurologische Begutachtung. By Dr. F. Stern. Berlin: Verlag Julius Springer. 1933. Pp. 189.

In this volume are set forth the views of German neurologists on various diseases of the nervous system. The opinions on so-called 'functional' disorder are of special interest. Many will disagree with the latter, as it is doubtful if any theory could be advanced that would satisfy all shades of neurological opinion. The work is well and clearly written.

Localization of Function in the Cerebral Cortex. By various authors. Vol. XIII, Publications of the Association for Research in Nervous and Mental Disease. Baltimore: Williams and Wilkins; London: Baillière, Tindall and Cox. 1934. Pp. 667. Price 36s.

This, the latest volume in their series of publications, is one of the largest issued under the auspices of the Association for Research in Nervous and Mental Disease. It is finely illustrated and documented, and may be claimed to embody the most recent work on the complex question with which it deals. The book, as is practically inevitable, is composed rather of a collection of individualized studies than of a conspectus over the whole field; its principal part deals with cerebral function as observed after lesions, small or large, neoplastic or vascular, natural or artificial. For example, frontal lobe function is inferred from partial bilateral frontal lobectomy (Brickner); observations (Penfield, German and others) based on more extensive lobectomies are utilized for the same purpose. It must always be matter for discussion whether the method throws as much light on normal function as is more or less tacitly assumed; we know that in the case of the cerebellum the technique has not fulfilled its promise. There are other items of deep interest in the book, not all of which are in reality related to its title, e.g. one dealing with the symptoms of cerebrovascular disease. Evidence is adduced here which suggests that the parietal lobe may exercise a 'trophic' influence on body musculature. Other communications have for their subject the visual cortex, and still others, epilepsy.

The Autonomic Nervous System. By Albert Kuntz, M.D., Professor of Anatomy in St. Louis University School of Medicine. Second edition, enlarged and revised. With 73 illustrations. London: Baillière, Tindall and Cox. 1934. Pp. 697. Price 35s.

During the few years that have elapsed since the first edition of Professor Kuntz's book appeared, research has been busy with the autonomic nervous

system, the consequence being that views are changing and conceptions widening. Moreover, from a practical standpoint considerably more attention is being engaged with the surgical aspect. These and other trends of the time are recognized and annotated in this new edition of a work which we esteem as one of the best that has ever been written on the sympathetic system. The caution of its author is wholly commendable; his knowledge of his subject is extensive; the clarity of the exposition leaves nothing to be desired. In its new form the book provides the reader with an up-to-date presentation, and is sure to be received and appreciated as generally as was its predecessor.